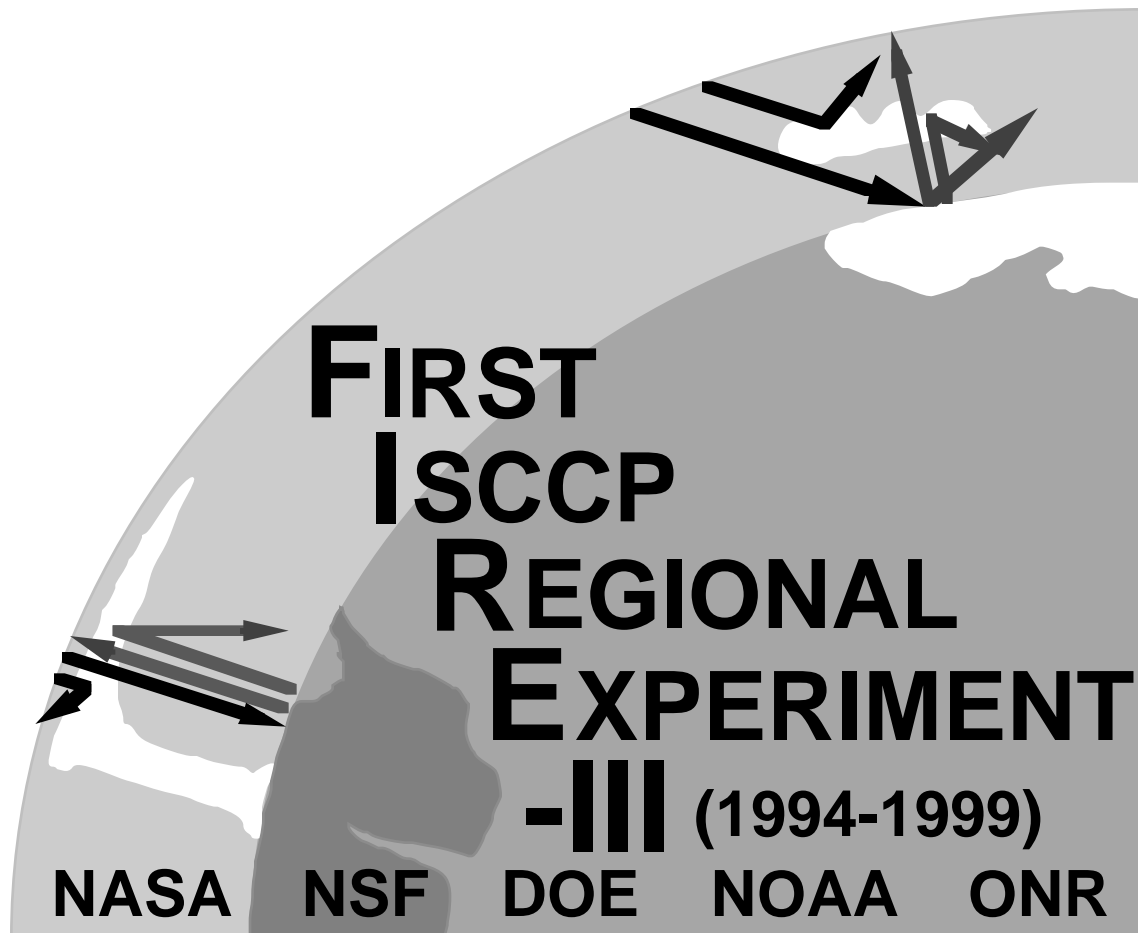


Revision B

FIRE Arctic Cloud Experiment Operations Plan

(A FIRE on the Ice)



Supported by:

**National Aeronautics and Space Administration
National Science Foundation
Department of Energy
National Oceanic and Atmospheric Administration
Office of Naval Research**

February 27, 1998

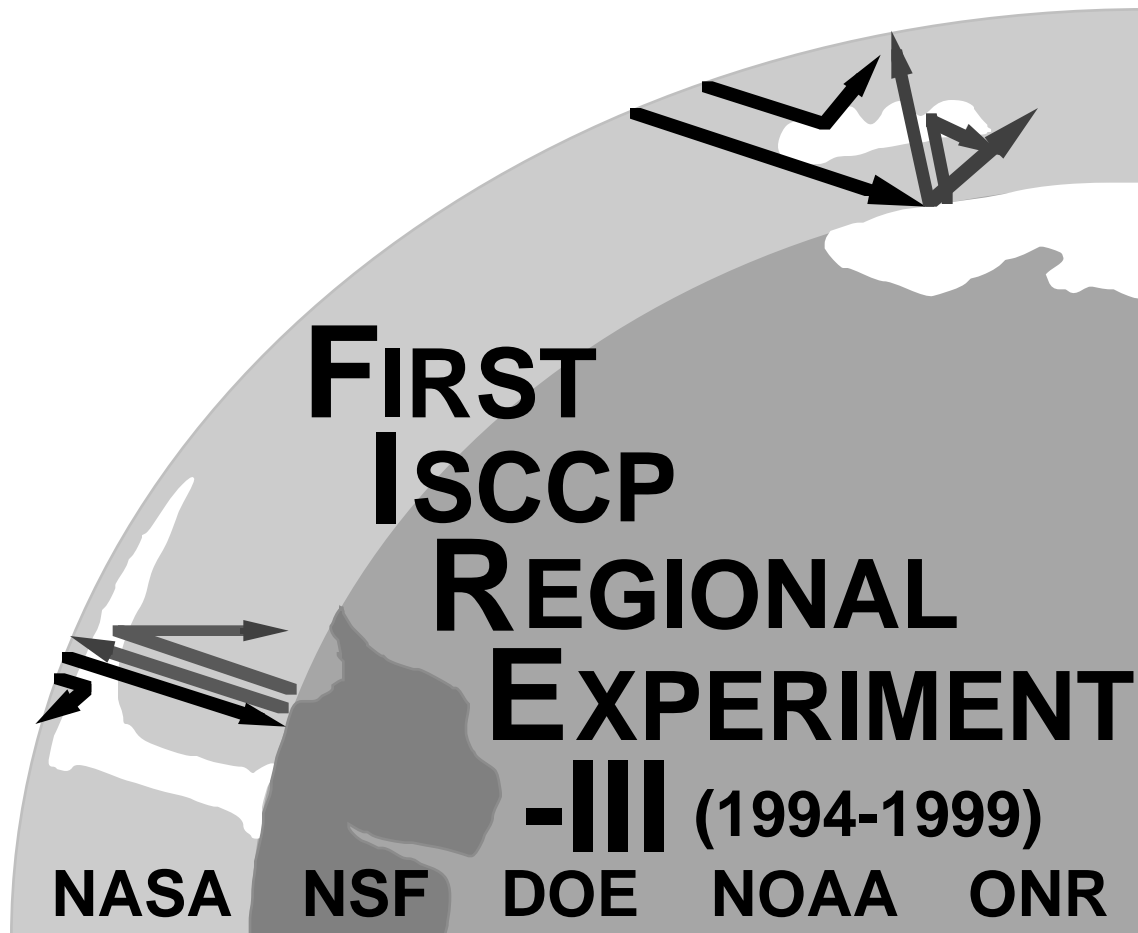
Fire and Ice

SOME say the world will end in fire, Some say in ice.
From what I've tasted of desire
I hold with those who favor fire.
But if it had to perish twice,
I think I know enough of hate
To know that for destruction ice
Is also great
And would suffice.

Robert Frost
(*Harper's*, December 1920)

FIRE Arctic Cloud Experiment Operations Plan

(A FIRE on the Ice)



Available from:
NASA Langley Research Center
FIRE Project Office
Mail Stop 483
Hampton, VA 23681-0001

757-864-5832
757-864-5841 (fax)
d.s.mcdougal@larc.nasa.gov (e-mail)

February 27, 1998

FIRE III ARCTIC CLOUD EXPERIMENT OPERATIONS PLAN

TABLE OF CONTENTS

TABLE OF CONTENTS.....	IV
1.0 BACKGROUND AND OVERVIEW.....	12
1.1 Operations Plan Overview	13
1.2 Arctic Cloud Experiment Objectives.....	13
1.3 Science Issues.....	14
1.3.1 Arctic Physical Processes and Climate Modeling.....	14
1.3.2 Arctic Measurement Validation.....	15
1.4 Location and Schedule of the FIRE Arctic Cloud Experiment.....	16
2.0 ARCTIC CLOUD EXPERIMENT WORKING GROUP.....	23
2.1 Working Group Members.....	23
2.2 Integration Task Teams.....	24
2.2.1 Satellite Remote Sensing Evaluation.....	25
2.2.2 Cloud Effects on Radiative Fluxes.....	25
2.2.3 Climate Modeling.....	25
2.2.4 Ground-based Sensors.....	26
2.3 Working Group Member Investigations	26
3.0 OPERATIONS COORDINATION AND OVERSIGHT.....	28
3.1 Experiment Planning, Implementation, and Oversight	28
3.2 Briefing, Planning, and Coordination Meetings	32
3.2.1 Daily Operations Planning Meeting.....	32
3.2.2 Flight-day Meetings.....	32
3.2.3 Periodic Reviews.....	33
3.3 Schedules.....	33
3.4 Weather Forecast Support.....	36
3.5 Daily Reports	37
3.6 Daily Mission Summaries	37
4.0 SURFACE OPERATIONS.....	39

4.1 SHEBA Ship (Ice Station).....	39
4.1.1 Overview.....	39
4.1.2 Ice Station Personnel and Management.....	40
4.1.3 Surface-Based Instrumentation.....	41
4.1.4 Mesoscale Array.....	44
4.2 ARM Barrow Site.....	45
4.2.1 Overview.....	45
4.2.2 Instrumentation.....	46
4.3 Forecast Operations.....	47
4.4 Instrumentation Operation Logs.....	49
4.5 Survival Training.....	49
5.0 AIRCRAFT OPERATIONS.....	ERROR! BOOKMARK NOT DEFINED.
5.1 Overview.....	38
5.2 Aircraft and Instrumentation Descriptions.....	38
5.2.1 NASA ER-2.....	38
5.2.2 UW CV-580.....	39
5.2.3 NCAR C-130Q.....	40
5.2.4 Canadian CV-580.....	41
5.2.5 NOAA Quicksilver GT500 "ULTRALIGHT".....	42
5.2.6 SHEBA Twin Otter.....	42
5.2.7 SHEBA Helicopter.....	42
5.3 Flight Planning Strategy.....	43
5.4 Flight Patterns.....	47
5.4.1 Cloudy Boundary Layer.....	48
Figure 5.4.1-2a Canadian CV-580 Cloud Characterization and Budget Flight Pattern.....	55
5.4.2 Clear Stable Boundary Layer.....	55
5.4.3 Clear Sky.....	56
5.4.4 Leads.....	56
5.4.5 Surface Sensor Validation.....	59
5.4.6 Surface Mapping.....	60
5.4.7 Cloud/radiation.....	60
5.4.8 Cloud Characterization.....	61
5.4.10 ER-2 coordinated missions with UW and Canadian Convairs and NCAR C-130.....	71
5.4.11 Aircraft/Satellite Intercomparisons.....	75
5.4.12 Convair/Surface Intercomparisons.....	76
5.4.13 SHEBA Aircraft.....	77
5.5 Schedules and Operations Constraints.....	78
5.5.1 Summary of Crew Duty Limits.....	78
5.5.2 Air Traffic Control Considerations.....	80
5.6 Aircraft Operations Logs.....	81
5.7 Safety, Flight Go/No-Go and Mission Abort Procedures.....	81

5.8 Survival Training.....	84
5.9 Preparation and Turnaround Times	84
5.10 Aircraft Operations in Vicinity of SHEBA Ship.....	85
6.0. SATELLITE OPERATIONS.....	86
6.1 Overview.....	86
6.2 Data Collection and Analysis	86
6.2.1 Special Satellite Retrievals and Validation Studies.....	89
6.2.2 Satellite Surveys.....	89
6.2.3 Diagnostic Studies.....	89
6.3 Support for Mission Planning	90
6.4 Surface-based Observations in Support of Satellite Data Analysis.....	90
6.5 Aircraft-based Observations in Support of Satellite Data Analysis.....	91
6.5.1 Satellite/Aircraft Radiometer Comparison Missions.....	92
6.5.2 In situ and Vertical Profile Measurements.....	92
6.5.3 Survey of Small-scale Variability.....	93
7.0 INSTRUMENTATION CALIBRATION.....	94
7.1 Calibration Documentation.....	94
7.2 Radiation Instrumentation Calibration	94
7.2.1 Broadband radiometers (surface and aircraft).....	94
7.2.2 Spectral sensors.....	94
7.2.3 Aircraft-to-surface.....	94
7.2.4 Aircraft-to-satellite.....	95
7.3 Microphysics Instrumentation Calibration.....	95
7.3.1 NCAR Microphysical Sensor Calibration Plan.....	95
7.4 Aircraft Microwave Instrumentation Calibration	96
8.0 DATA SETS AND MODELING OPERATIONS.....	97
8.1 Arctic Climate Processes and Modeling Datasets.....	97
8.1.1 Instantaneous Radiative Flux Dataset.....	97
8.1.2 Single-column Dataset.....	98
8.1.3 Large-eddy Simulation Dataset.....	100
8.2 Arctic Measurement Validation Dataset	100
8.2.1 Validation of Surface Sensors with In-Situ Aircraft and Balloon Measurements.....	100
8.2.2 Validation of Satellite based sensors with Surface Measurements.....	101
8.2.3 Measurement Variables for the Validation Data Set.....	101
8.3 Operational Models.....	101

9.0 COMMUNICATIONS.....	104
9.1 Overview.....	104
9.2 Radio, Telephone, Satellite, and GTS Links.....	105
9.2.1 Telephones and Fax.....	106
9.2.2 Cellular Telephones.....	107
9.2.3 Internet.....	107
9.2.4 Telephone Policy.....	109
9.3 Aircraft Communications	109
9.4 Web Pages	112
10.0 DATA MANAGEMENT.....	115
10.1 Data Protocol and Publications Plan.....	115
10.1.1 Data Protocol.....	115
10.1.2 Data Publication.....	116
10.2 Data Management Responsibilities.....	117
10.2.1 Working Group.....	117
10.2.2 Principal Investigators.....	118
10.3 Data Archival.....	119
10.3.1 Langley DAAC.....	120
10.3.2 Sheba Data Archive.....	121
10.3.3 ARM Data Archive.....	121
10.3.4 NCAR Data Archive.....	122
10.3.5 NOAA CMDL Data Archive.....	122
10.4 Data Products.....	122
10.5 Data Categories.....	124
10.6 Data Management Schedule.....	125
10.7 Data Exchange with SHEBA and ARM.....	126
10.7.1 SHEBA Introduction and Background.....	126
10.7.2 SHEBA Data Management Policy.....	127
10.7.3 SHEBA/JOSS Data Management System.....	128
10.7.4 SHEBA Coordination with Data Centers and other Agencies.....	129
10.7.5 ARM Data.....	130
11.0 LOGISTICS.....	132
11.1 Time Definition.....	132
11.2 Shipping.....	132
11.3 Travel Arrangements.....	133

11.4 Facilities	133
11.5 On-Site Project Office Support.....	135
11.6 Fort Wainwright and U. AK-GI Support.....	136
11.7 Medical Considerations	136
11.8 Insurance Considerations	136
11.9 Alcohol Restrictions	136
11.10 Site Locations.....	141
11.12 Personnel Access to Facilities.....	141
11.13 Personnel Rosters	142
APPENDIX A--REFERENCES.....	1
APPENDIX B--ACRONYMS.....	1
APPENDIX C--SATELLITES, SENSORS, AND DATA PRODUCTS.....	1
C.1 NOAA Polar-orbiting Operational Environmental Satellite (POES).....	1
C.1.1 Introduction.....	1
C.1.2 Data.....	2
C.1.3 AVHRR.....	2
C.1.4 GAC Data.....	4
C.1.5 LAC/HRPT Data.....	4
C.1.6 HIRS/2.....	4
C.2 DMSP.....	6
C.2.1 SSM/I DESCRIPTION.....	6
C.2.2 SSM/T2 DESCRIPTION.....	7
C.3 RADARSAT/SAR.....	8
C.3.1 Summary.....	8
C.3.2 Synthetic Aperature Radar(SAR).....	9
C.4 RESURS/SCARAB 2.....	13
C.5 Earth Probe.....	14
C.6 LANDSAT.....	14
APPENDIX D--AIRCRAFT, SENSORS, AND DATA PRODUCTS.....	1
D.1 NCAR C-130Q Instruments.....	1
D.1.1 Description of Radiation Measurement System(RAMS).....	2
D.1.2 Airborne Imaging Microwave Radiometer(AIMR).....	4

D.1.3	Multichannel Cloud Radiometer(MCR).....	4
D.1.4	Cloud Particle Imager(CPI).....	5
D.1.5	CFD Chamber and CN Counter.....	5
D.1.6	CCN Spectrometers and CN Counter.....	7
D.1.7	NCAR Cloud Statistics Data Product.....	7
D.2	NASA ER-2 Instruments.....	9
D.2.1	Solar Spectral Flux Radiometer (SSFR).....	9
D.2.2	MODIS Airborne Simulator(MAS).....	10
D.2.3	Millimeter-wave Imaging Radiometer(MIR).....	13
D.2.4	Advanced Microwave Precipitation Radiometer(AMPR).....	13
D.2.5	Scanning High-resolution Interferometric Sounder (SHIS).....	15
D.2.6	Cloud Lidar System(CLS).....	15
D.2.7	Airborne Multi-angle Imaging Spectro-Radiometer(AirMISR).....	16
D.3	UW CV-580 Instruments.....	17
D.3.1	Solar Spectral Flux Radiometer (SSFR).....	21
D.3.2	Cloud Absorption Radiometer.....	21
D.4	Canadian CV-580 Instruments.....	23
D.4.1	Lidar.....	25
D.4.2	U. of Arizona Radiometer.....	26
D.4.3	LANDSAT Simulator.....	26
D.5	SHEBA Ultralight.....	26
D.6	SHEBA Twin Otter	27
D.7	SHEBA Helicopter.....	27
APPENDIX E--SURFACE-BASED INSTRUMENTATION AND DATA PRODUCTS.....		1
E.1	SHEBA -Ship	1
E.2	ARM -Ship.....	4
E.3	ARM - Barrow	5
E.4	FIRE -Ship.....	8
E.4.1	University of Utrecht.....	8
E.4.2	Solar Spectral Flux Radiometer (SSFR).....	11
E.5	Buoys.....	12
APPENDIX F--SHEBA SHIP(ICE STATION).....		1
F.1	Overview.....	1
F.2	SHEBA Ship Facilities.....	1
F.3	Schedules and Operations Constraints.....	2

APPENDIX G--DATA PARAMETERS.....	1
APPENDIX H--LANGLEY DAAC DATA SET INGEST REQUEST.....	1
H.1 Data Set Description	1
H.2 Data Set Processing History.....	2
H.3 Browse Products.....	5
H.4 Data Delivery.....	6
H.5 Read Software.....	6
H.6 User Community.....	7
H.7 Documentation.....	7
H.8 References.....	8
APPENDIX I --LOCAL INFORMATION.....	1
I.1 ALASKA.....	1
I.2 FAIRBANKS.....	5
I.3 BARROW.....	9
APPENDIX J: ARCTIC CLOUD MISSION.....	1
PARTICIPANT LIST.....	1
APPENDIX K--OPERATIONAL LOG FORMS.....	1
APPENDIX L--PARTICIPATION AGREEMENT BETWEEN SHEBA AND FIRE1	
APPENDIX M--AGREEMENT BETWEEN ECMWF AND FIRE.....	1
APPENDIX N--MEMORANDUM OF AGREEMENT BETWEEN U. S. ARMY AND FIRE.....	1
APPENDIX O--MEMORANDUM OF AGREEMENT BETWEEN U. AK-GI AND FIRE.....	1
APPENDIX P--ARM/FIRE AGREEMENT.....	1
APPENDIX Q--SATELLITE OVERPASS PREDICTIONS.....	1

Q.1 NOAA 12 and 14.....	1
Q.2 DMSP F12 and F13.....	8
Q.3 RADARSAT.....	10
Q.4 Earth Probe.....	10
Q.5 RESURS.....	10
Q.6 LANDSAT.....	10

1.0 BACKGROUND AND OVERVIEW

The following are the objectives for the First ISCCP Regional Experiment (FIRE) Phase III Program. They relate both to previous data collected during FIRE I and FIRE II on midlatitude, subtropical, and tropical cirrus and midlatitude marine stratocumulus cloud systems and to future research associated with upper tropospheric cirrus and high latitude (Arctic) cloud systems.

- Apply FIRE Phase I and II model and field campaign results to the improvement and evaluation of cloud-system parameterizations employed in large eddy simulation (LES) and global climate models (GCMs).
- Apply FIRE Phase I and II field campaign and theoretical results to develop and verify improved techniques for the inference of cloud radiative and microphysical properties from satellite and surface-based data.
- Define the total water substance (vapor, liquid and ice) environment and transports associated with cloud systems.
- Define, design, test and implement measurement systems to observe key microphysical and radiative properties of cirrus and boundary layer clouds and cloud systems.
- Advance our understanding of climatically important cloud systems, the variability of their microphysical and radiative properties, the key processes involved in the formation and dissipation, and their roles in regulating the flow of energy between the surface and the atmosphere.
- Provide a methodical transition from FIRE Phases I and II accomplishments to a coherent research plan for the next generation of research on climatically important cloud systems.

An overview of the FIRE program to date is given by Randall et al. (1995). FIRE Phase I (1984- 1989) was designed to address fundamental questions concerning the maintenance of cirrus and marine stratocumulus cloud systems (Bretherton et al., 1983; FIRE Implementation Plan, 1985). FIRE research over those years has led to major improvements in our understanding of the role of these clouds in the global climate system. FIRE Phase II (1989-1994) focused on more detailed questions concerning the formation, maintenance, and dissipation of these cloud Systems. FIRE Phase III will continue with the above, plus commence an investigation of Arctic cloud systems.

FIRE is now preparing to go to the Arctic in order to study a variety of Arctic cloud systems under spring and summer conditions. At the same time, analysis of previously collected FIRE data will continue. An overview of our present understanding of Arctic cloud and radiation properties and processes is given by Curry et al. (1996). Critical questions regarding arctic clouds and radiation have been recently articulated by the SHEBA Prospectus (Moritz et al., 1993), the ARM Science Plan (1996), Ellingson et al. (1998), the FIRE III Research Plan (Cox et al., 1994) and the FIRE III Implementation Plan (Randall et al. 1996). A complete discussion of the science background is provided by these documents. The primary motivations for the Arctic phase of FIRE are:

- the physical processes at work in the Arctic cloudy boundary layer are poorly understood;
- satellite remote sensing algorithms currently cannot accurately retrieve Arctic surface and cloud characteristics;
- arctic boundary-layer clouds are poorly simulated by current climate models.

1.1 Operations Plan Overview

This Operations Plan describes the FIRE III research platforms and instruments for the Arctic Cloud Experiment, presents plans for their effective and accurate use, and specifies the coordination, evaluation and decision-making processes and communications and support systems necessary for operational success. The plan is concerned with all operations from data acquisition through the process of making data available to the FIRE Science Team Members. This Plan also describes SHEBA and ARM platforms and instruments which will provide measurements of interest to FIRE objectives. This document has two important predecessors: the FIRE Phase III Research Plan and the FIRE Phase III Arctic Implementation Plan. Appendices A and B contain references and acronyms/abbreviations for the whole document.

1.2 Arctic Cloud Experiment Objectives

The overall objective of the FIRE Arctic Cloud Experiment is to produce an integrated data set that:

- supports the analysis and interpretation of physical processes that couple clouds, radiation, chemistry and the atmospheric boundary layer;
- provides in situ data for testing satellite, aircraft and surface-based remote sensing analyses; and
- provides initial data, boundary conditions, forcing functions, and test data to support Arctic FIRE cloud modeling efforts.

The scientific payoff from FIRE does not come merely from collecting a set of measurements, even if the set is comprehensive and some of it has been analyzed to retrieve key quantities. Rather the real payoff comes from using the retrieved results to answer questions about what is going on in the Arctic. The key overarching question for FIRE is:

How do the radiative feedback processes occurring between the clouds and the sea ice surface influence the Arctic energy balance?

The subsidiary questions are:

- What are the properties of Arctic clouds, including their synoptic and annual variations?
- How do Arctic clouds alter radiative exchanges between the surface, atmosphere and space?
- Why are these particular clouds produced in the Arctic?

To answer these questions from observations requires, first, the reduction of the measurements of the most important quantities that are associated with the controlling cloud

and radiative processes, with particular emphasis on characterizing the variations of these quantities over the relevant space and time scales that are indicative of the processes at work. To cover these scales requires employing many remote sensing observations which need to be validated for the difficult Arctic conditions.

1.3 Science Issues

The detailed science questions to be addressed by the FIRE III Arctic Cloud Experiment are summarized below.

1.3.1 Arctic Physical Processes and Climate Modeling

Key questions relating to Arctic clouds are as follows:

- (1) What is the influence of leads and other open water on cloud properties when there is a large surface temperature contrast with the ice?
- (2) How does the extreme static stability and low atmospheric water vapor content of the Arctic lower troposphere, particularly in wintertime, affect the flow of energy across the air-sea interface?
- (3) What is the mechanism that leads to the prevalence of multi-layered cloud systems in the summertime Arctic?
- (4) What is the vertical structure of Arctic clouds in wintertime and how does the vertical cloud structure affect precipitation?
- (5) How does the transition of low clouds from liquid to crystalline depend on temperature and aerosol characteristics, and how does the springtime transition differ from the autumnal transition?
- (6) Does the formation of diamond dust differ in polluted vs. unpolluted atmospheres?

Key questions related to Arctic radiation are as follows:

- (7) What is the spectral distribution of longwave radiation and, in particular, what is the role of the 20 μm rotation-band wavelength region in regulating the surface and atmospheric temperatures in the Arctic?
- (8) What are the effects of springtime Arctic haze on the absorption of solar radiation in clouds?
- (9) How do the reflectance and transmittance of the clouds and the surface depend on the low solar zenith angles typical of the Arctic?
- (10) How does “clear-sky” ice crystal precipitation affect the radiative fluxes?
- (11) What are the short-wave radiative effects of the horizontally inhomogeneous stratocumulus clouds over the horizontally inhomogeneous, highly-reflecting snow/ice surface?
- (12) How do the optical properties of the Arctic surface vary in response to changes in the structure of surface frost deposits (strong function of temperature and supersaturation) and changes in snow characteristics (thickness, age, temperature, contamination), thinning of the ice, and melt pond formation?

Key questions regarding the chemistry of the Arctic atmosphere are as follows:

- (13) What are the actual supersaturations at which various cloud condensation nuclei (CCN) are activated?
- (14) What is the shape of the CCN spectrum?
- (15) Which aerosol particles are actually incorporated into droplets?
- (16) What is the chemical composition of the CCN; in particular are organics involved?
- (17) How do the CCN distributions interact with the cloud droplet distributions?
- (18) What is the nature of the ice freezing nuclei (IFN) and/or the CCN and how do they effect the temperature at which water droplets freeze?
- (19) What is the relative importance of droplet freezing vs. the freezing of sulfuric acid in the formation of diamond dust?

The Arctic Mission dataset required to address arctic physical process questions is described in section 8.1.

1.3.2 Arctic Measurement Validation

The FIRE observations rely heavily on remote sensing measurements from aircraft and satellites (and there are also a number of surface remote sensing instruments at the SHEBA and ARM sites). Appeal will be made to these data to cover the necessarily large ranges of space and time scales over which clouds and radiation vary. In situ measurements on the surface and from aircraft, which do not cover the necessary range of scales, are needed to validate these remote sensing measurements. Since each observing system covers different combinations of space and time scales, the measurement strategy is to use in situ aircraft observations to verify inferences obtained from surface and aircraft remote sensing measurements and then to use the longer data records from the surface remote sensing instruments to validate inferences from satellite observations. However, some questions concerning the effects on radiative fluxes of the interaction of horizontal and vertical inhomogeneity of clouds and the combined horizontal inhomogeneity of clouds and sea ice will also require some aircraft-to-satellite comparisons.

Key questions regarding aircraft-to-surface comparisons of Arctic measurements are:

- (20) For different cloud conditions (e.g. single vs multiple layers, ice vs liquid vs mixed phase) what is the accuracy of surface based retrievals of cloud microphysical and optical properties?
- (21) How do vertical variations of cloud and atmospheric properties relate to variations of radiative flux profiles and surface radiation fluxes?
- (22) How do time variations at the surface sites relate to horizontal variations of clouds?
- (23) How do aircraft modify the microphysics of the clouds they are sampling, and how does this affect the accuracy of their in-situ measurements?

(24) How can aircraft in-situ measurements provide information to assist in the development of combined radar-lidar-radiometer techniques to characterize the microphysical and optical properties of mixed phase clouds.

Key questions regarding aircraft-to-satellite comparisons of Arctic measurements are:

(25) What are the characteristics of the horizontal variations of cloud and surface properties on spatial scales from 100 m to 100 km?

(26) How are the horizontal variations of radiative fluxes above and below clouds related to the horizontal variations of cloud and surface properties?

(27) How do vertical variations of cloud properties affect interpretation of satellite measurements of clouds?

Key questions regarding satellite-to-surface comparisons of Arctic measurements are:

(28) How do the vertical variations of cloud and atmospheric properties affect the interpretation of the measurements of clouds made by satellite remote sensing instruments?

(29) How representative of the whole Arctic are the clouds, atmosphere and surface properties at the two surface sites?

(30) How well can the surface and atmospheric radiative fluxes be re-constructed from satellite-based observations?

(31) What are the size and time scales of various cloud properties?

(32) What are the appropriate averaging periods for surface data so they can be meaningfully compared to satellite data. Do these averaging periods vary significantly as a function of cloud height and/or cloud type?

(33) How accurately can satellites detect the presence of clouds over ice?

(34) What is the radiative significance of clouds which cannot be accurately detected by satellite?

The Arctic Mission dataset required to address arctic measurement validation questions is described in section 8.2.

1.4 Location and Schedule of the FIRE Arctic Cloud Experiment

The general area of interest is Alaska and the adjacent Arctic Ocean (Figure 1.4-1), specifically the Beaufort Sea because of its accessibility for U.S. platforms. The location and time of the FIRE Arctic Cloud Experiment are somewhat constrained by the SHEBA experimental site, which is a ship in the Beaufort Sea during the period mid-September 1997 through the end of October 1998.

The location of the temporary research station is determined by the following constraints:

- the ice floe and vicinity, must be of sufficient size and variability to contain numerous surface features that vary in horizontal area and physical properties

- over the course of the experiment (such as bare ice, snow cover, melt ponds, leads, hummocks, ridges and ice of different thicknesses)
- the station must be far enough from the continental shelf and from the ice edge

Figure 1.4-1. General Area of Interest



- the station must be accessible by aircraft operating from North American coastal airports.

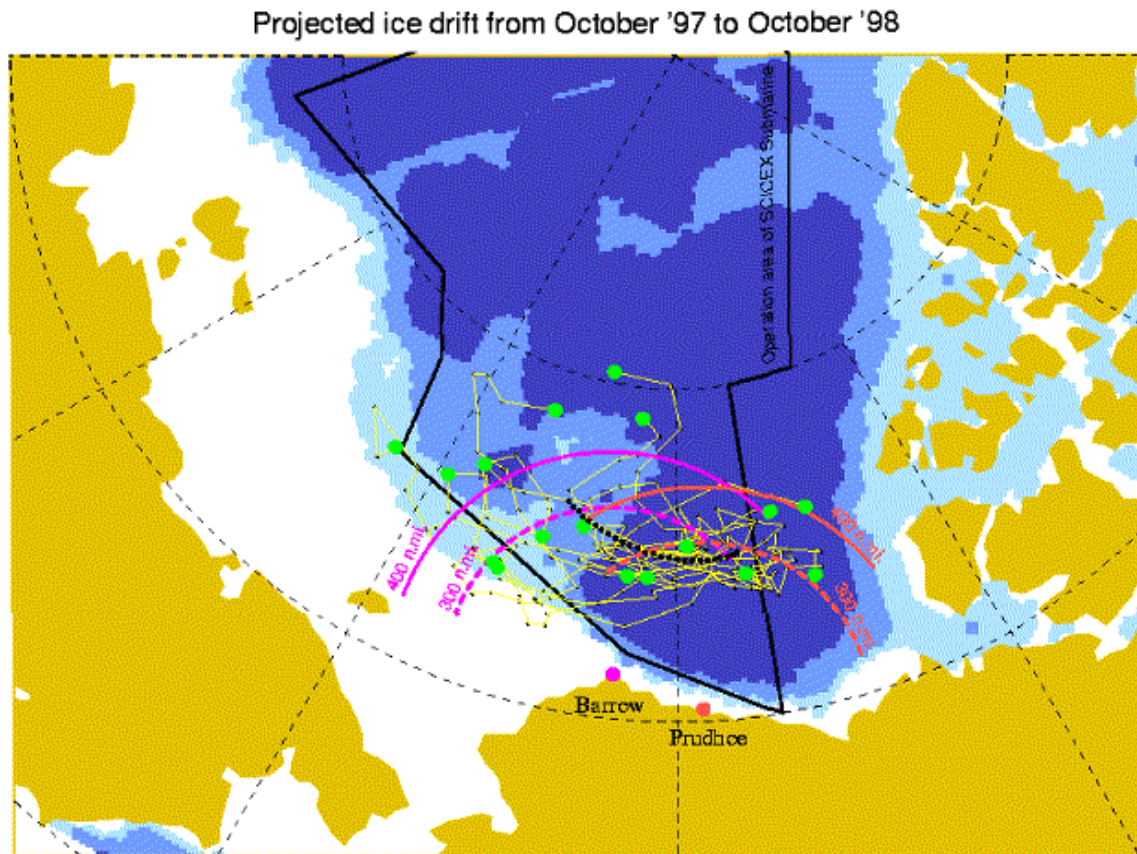
The scientific and operational considerations indicate that the optimal site for deploying the SHEBA camp is in the eastern Beaufort Sea in the vicinity of 75°N and 145°W (the location was 75.5N , 149.1W on 12/7/97 and the current location can be determined from Don Wylie's homepage--sect. 9.5). Figure 1.4-2 illustrates the probable trajectory of a station deployed at that location, taking into account the mean and variability of the sea-ice velocity documented by the Arctic Buoy Program during 1979-1993. Figure 1.4-3 indicates the Ice Camp trajectory since its insertion into the iceflow in late October 1997.

Additional surface observations will be obtained at Barrow in conjunction with the ARM site. The focus of the aircraft campaigns will be over the SHEBA and Barrow sites. The satellite measurements will be centered over the SHEBA and Barrow sites.

During the aircraft field campaigns, the primary FIRE operations center will be located at Fairbanks, AK, which will serve as the base for the NASA ER-2 and NCAR C-130

aircraft. The UW Convair will operate out of Barrow. The Canadian Convair will operate out of Inuvik.

Figure 1.4-2. Ice Camp Probable Trajectory



This figure shows the projected drift of the SHEBA camp (75N 143W) using data from the Arctic Buoy Program from 1979-1996. The black dots show the mean drift of the camp from October 1, 1997 to October 31, 1998. The green trajectories show the interannual variability of ice motion. If the camp had been deployed in any year from 1979 through 1995, the camp would have followed one of these trajectories. The large green dots show the final positions in October the following year.

1.4-3. Ice Camp Actual Movement since Insertion into Iceflow

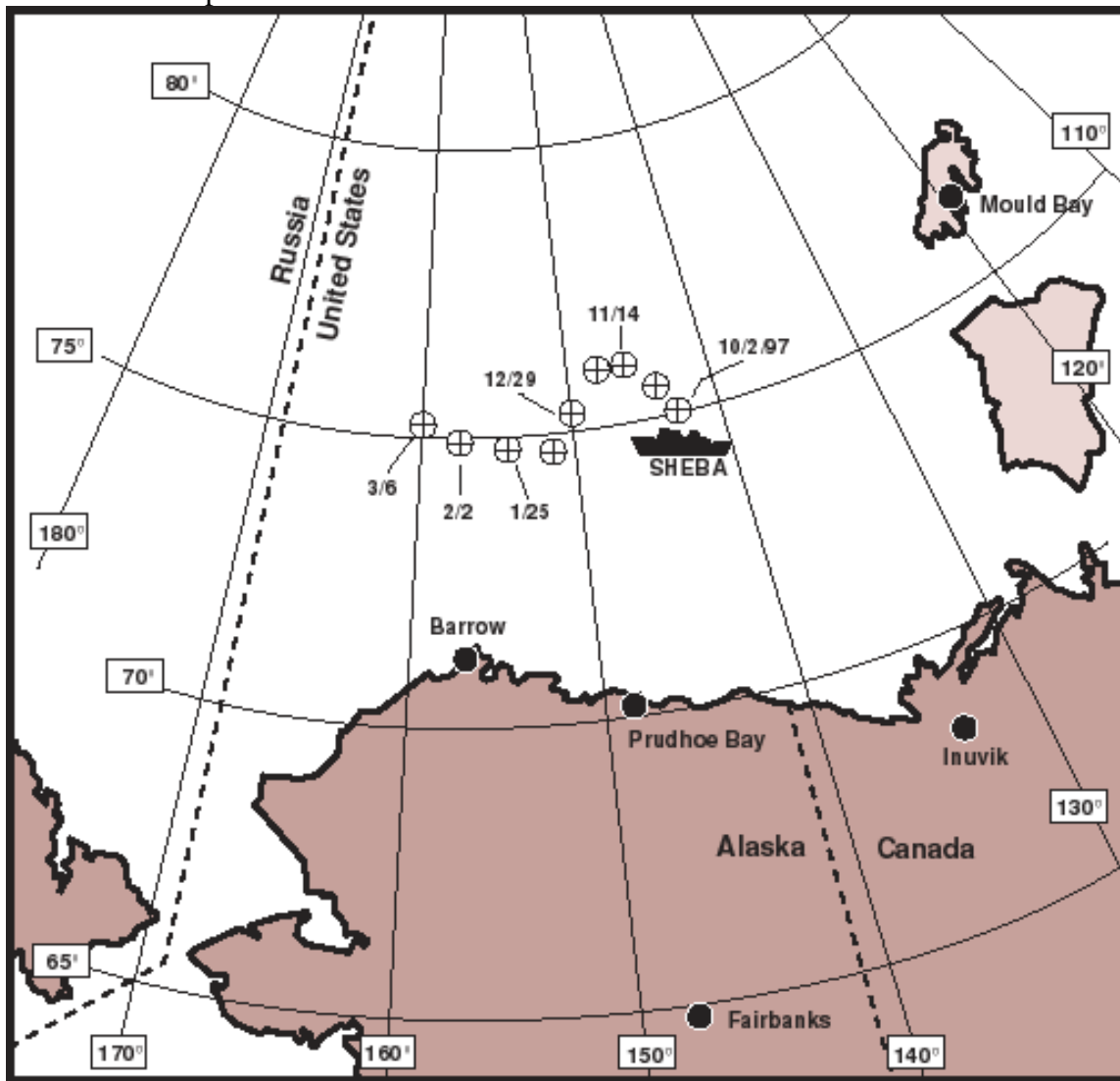


Table 1.4-1 and figure 1.4-4 show the anticipated schedule for field operations. Figure 1.4-5 shows the area of operations and operational bases.

Table 1.4-1. Arctic Cloud Experiment Schedule of Aircraft Operations

Phase	Season	Thrust	Aircraft	Period
Phase I	Spring 1998	FIRE Arctic Cloud Experiment & SHEBA	Canadian CV-580 NCAR C-130 NASA ER-2 UW CV-580 Quicksilver GT 500 Twin Otter Helicopter	April 7 - May 4 May 4-28 May 15 - June 7 May 15 - June 13 April 13-May 20 every 3-6 weeks every 3-4 days
Phase II	Summer 1998	SHEBA	NCAR C-130 Ultralight Twin Otter Helicopter	July 6-July 30 TBD every 3-6weeks every 3-4 days

Figure 1.4-4 FIRE.ACE Schedule as of 1/23/98

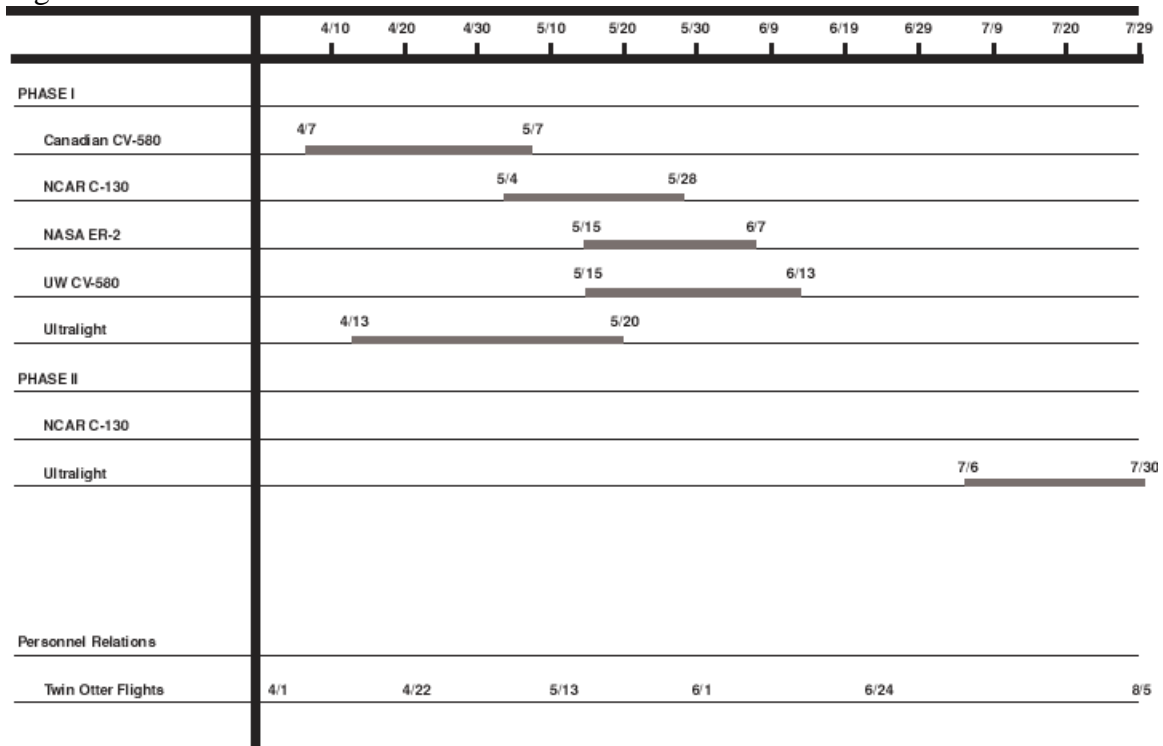
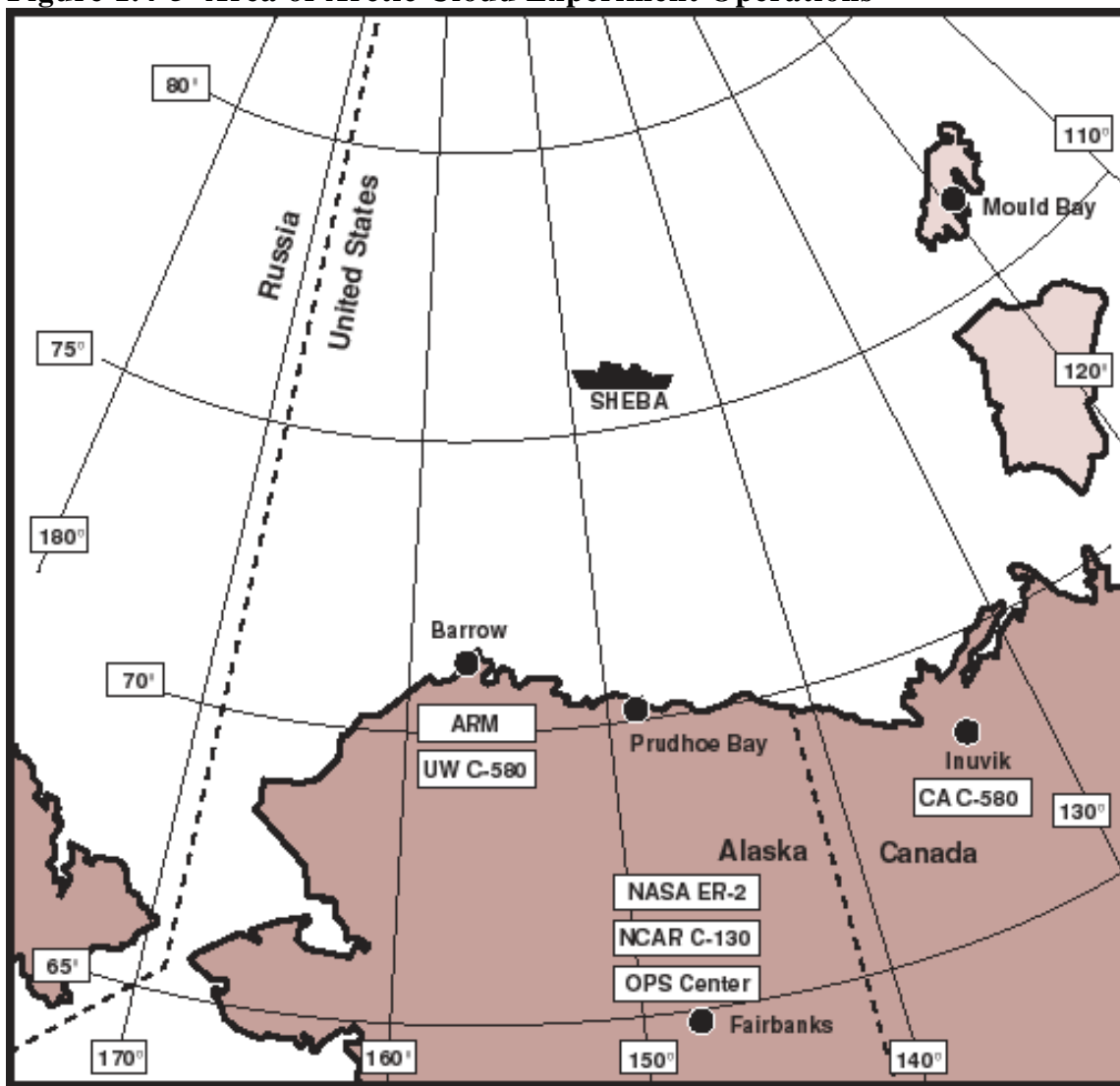


Figure 1.4-5 Area of Arctic Cloud Experiment Operations



2.0 ARCTIC CLOUD EXPERIMENT WORKING GROUP

2.1 Working Group Members

Selected members of the FIRE III Science Team serve as members of the Arctic Cloud Working Group. They guide the design of the experiment, some will make measurements during the field phase, and all will analyze the measurements to develop answers for the science issues in section 1.3, above. The members of the Arctic Cloud Working Group, also referred to as the Arctic Cloud Experiment Science Team, are listed in table 2.1-1.

Table 2.1-1. FIRE Arctic Cloud Working Group Members

Name	Institution	Role
Chris Bretherton	U. Washington	Modeling Analyses
Ken Campana	NOAA-NCEP	Modeling Analyses and RTNEPH Analysis
Judy Curry	CU	Lead Mission Scientist and C-130 Scientist
Tony Del Genio	NASA-GISS	Modeling Analyses
Wynn Eberhard	NOAA-ETL	Surface Data Acquisition and Analyses
Chris Fairall	NOAA-ETL	Surface Data Acquisition and Analyses
Hermann Gerber	Gerber Scientific	UW CV-580 G-meter
John Hallett	U. NV- DRI	Canadian CV-580 Replicator and Cloudscope
Peter Hobbs	U. Washington	UW CV-580 Scientist
Jim Hudson	U. NV-DRI	C-130 CCN & CN
George Isaac	AES	Canadian CV-580 Scientist
Michael King	NASA GSFC	ER-2 Scientist
Yefim Kogan	U. OK	Modeling Analyses
Sonia Kreidenweis	CSU	C-130 IFN
Steven Krueger	U. Utah	Modeling Analyses
Paul Lawson	SPEC Inc.	C-130 CPI
Don Lenschow	UCAR	C-130 Turbulence Analysis
Martin Miller	ECMWF	Model Progs and Analyses
Pat Minnis	NASA LaRC	AVHRR HRPT Data
Peter Pilewskie	NASA ARC	SHEBA Ship, UW CV-580 and ER-2 SSFR
David Randall	CSU	Arctic Cloud Science Team Chair
Bill Rossow	NASA GISS	Satellite Scientist
Jim Spinhirne	NASA GSFC	ER-2 CLS
Si-Chee Tsay	NASA GSFC	ER-2 MAS & UW CV-580 CAR
Taneil Uttal	NOAA-ETL	Surface Scientist
Francisco Valero	NASA ARC	NCAR C-130 RAMS
Shouping Wang	NASA MSFC	Modeling Analyses
Bruce Wielicki	NASA LaRC	Satellite Analyses
Don Wylie	U. Wisconsin	Lead Forecaster
Qing-Yu Zhao	NOAA-NCEP	Modeling Analyses

In addition to the Fire Science Team members who compose the Arctic Cloud Working Group, there are FIRE Instrument Investigators who will be participating in the

experiment. They will have access to all experiment data and have agreed to abide by the data protocol of section 10.1. Their names are included in Table 2.1-2.

Table 2.1-2. FIRE Instrument Investigators

Name	Organization	Role
Roger Marchand	PSU	ER-2 AirMISR
Peter Duynkerke	U. Utrecht	Ice Camp Tethered Balloon
Robbie Hood	NASA MSFC	ER-2 AMPR
Dave Rogers	Colorado State Univ.	C-130 Ice Freezing Nuclei
Hank Revercomb	U. of Wisc.	ER-2 SHIS
Jim Wang	NASA-GSFC	ER-2 MIR

Selected members of the SHEBA Science Team are designated adjunct members of the FIRE III Science Team in order to facilitate data exchange and publication. They have agreed to abide by the data protocol as presented later in section 10.1. The names of the adjunct SHEBA Science Team members on the FIRE Science Team are listed in Table 2.1-3.

Table 2.1.-3. Adjunct SHEBA Science Team Members on the FIRE Science Team

Name	Institution	Role
Jim Overland	NOAA/PMEL	Surface Heat Budget
Don Perovich	Army/CRREL	Ice/Albedo Feedback Processes
Knut Stamnes	U. Alaska-Fairbanks	ARM Barrow Site Scientist
Steve Brooks	NOAA/ATTD	Ultralight Flights

Selected members of the FIRE Arctic Cloud Working Group are members of the SHEBA Science team and will facilitate data exchange and publication. They have agreed to abide by both FIRE and SHEBA data protocols. The names of the FIRE Arctic Cloud Working Group members on the SHEBA Science Team are listed in Table 2.1-4.

Table 2.1-4. FIRE Arctic Cloud Working Group Members on the SHEBA Science Team

Name	Institution	Role
Judy Curry	U. Colorado	Lead Mission Scientist
Chris Fairall	NOAA-ETL	Surface Data Acquisition and Analysis
Steven Krueger	U. Utah	Modeling Analyses
Taneil Uttal	NOAA-ETL	Surface Scientist

2.2 Integration Task Teams

The FIRE Arctic Cloud Experiment is not complete until combined analyses of observations from many platforms are integrated to address the main scientific questions. Therefore, to insure that adequate attention is paid to coordinating research efforts to accomplish these combined diagnostic studies, four Integration Task Teams have been formed from the Arctic Cloud Science Team membership. These teams will be responsible for informing the larger team of observation and data reduction needs and for encouraging and coordinating research that leads to integrated datasets and analysis results.

2.2.1 Satellite Remote Sensing Evaluation

This Integration Task Team (co-leaders: B. Wielicki and M. King) will focus on the following tasks related to arctic measurement validation:

- (1) evaluate the treatment of radiative transfer in ice clouds and quantify uncertainties in retrieval of ice cloud properties from satellites,
- (2) quantify the effects of small-scale horizontal variability and vertical structure in clouds on remote sensing analyses of their properties,
- (3) check the accuracy of temperature retrievals in inversion conditions,
- (4) check the accuracy of humidity profiles obtained from infrared and microwave satellite instruments, and
- (5) evaluate current surface temperature and albedo retrieval methods.

Other team members: Curry, Eberhard, Gerber, Isaac, Kogan, Lawson, Uttal, Duynkerke, Minnis

2.2.2 Cloud Effects on Radiative Fluxes

This Integration Task Team (co-leaders: W. Rossow and S. Pilewskie) will focus on the following tasks related to arctic physical processes:

- (6) compare calculated surface radiative fluxes and flux profiles to surface and aircraft observations, respectively, as function of cloud and atmospheric properties,
- (7) quantify uncertainties and their causes in the treatment of ice phase clouds,
- (8) evaluate effects on radiative fluxes of large cloud particle size changes or phase changes with altitude,
- (9) evaluate treatment of shortwave fluxes at extremely low solar zenith angles,
- (10) evaluate effects of vertical and horizontal inhomogeneities on remote sensing and radiative fluxes,
- (11) confirm spectral dependence of fluxes under various meteorological conditions, and
- (12) incorporate combined datasets for more comprehensive heating/cooling rate profile diagnosis.

Other team members: Gerber, Hobbs, Isaac, Kogan, Lawson, Valero, Intrieri, Orr, Duynkerke, Rogers, Minnis

2.2.3 Climate Modeling

This Integration Task Team (co-leaders: C. Bretherton and J. Curry) will provide a small planning group to communicate the evolving data analysis needs of the model investigations to the FIRE team and to coordinate the proposed model experiments. Specific tasks related to arctic climate modeling include the following:

- (13) compile (with the help of the whole FIRE team) comprehensive case study datasets, including atmospheric large scale circulation, boundary layer turbulence, cloud and surface properties;
- (14) compile simulations of these case studies from column models, LES models and GCMs; and
- (15) diagnose moisture fluxes and radiative fluxes and their seasonal variations.

Other team members: Krueger, Randall, Campana, Del Genio, Isaac, Kogan, Duynkerke, Q. Wang, Hudson, S. Wang

2.2.4 Ground-based Sensors

This Integration Task Team (co-leaders: S. Krueger and T. Uttal) will seek to ensure that measurements from ground-based remote sensors are processed in ways that will allow them to be integrated with measurements from other platforms (surface, rawinsonde, and satellite), and to be used to evaluate cloud-scale model simulations. Specific tasks include the following related to arctic measurement validation:

(16) ensuring that whole sky imager, ceilometer, lidar, cloud radar, and microwave radiometer measurements at the SHEBA site are processed (by relevant FIRE/SHEBA/ARM team members) to obtain time series averages of cloud amount, cloud base and top heights, cloud fraction profile, particle size and concentration, optical depth, liquid water path and content profiles and ice water path and content profiles every ten minutes.

(17) ensuring that surface broadband solar and IR radiometer measurements at the SHEBA site are processed (by relevant FIRE/SHEBA/ARM team members) to obtain time series of areally and hourly averaged downwelling and upwelling surface solar and IR fluxes.

Other team members: Eberhard, Intrieri, Isaac, S. Wang, Duynkerke

2.3 Working Group Member Investigations

The Arctic Cloud Working Group members have provided a preliminary indication of the Arctic Cloud Experiment science issues in which they plan to be involved. Table 2.3-1 identifies which members will be involved with each issue.

Table 2.3-1 Working Group Member Investigations

Science Issue (Section 1.3)	Investigator
(1)	Curry, Del Genio, Hobbs, Isaac, Krueger, Randall, Q. Wang, Rogers, Lenschow
(2)	Campana, Curry, Isaac, Q. Wang, Lenschow, Rossow
(3)	Curry, Del Genio, Eberhard, Hobbs, Isaac, Krueger, Randall, S. Wang, Duynkerke, Q. Wang, Bretherton, Uttal
(4)	Campana, Curry, Del Genio, Eberhard, Hobbs, Isaac, Krueger, Q. Wang, Rogers, Bretherton, Uttal
(5)	Curry, Del Genio, Eberhard, Hallett, Hobbs, Isaac, Kogan, Krueger, Lawson, S. Wang, Q. Wang, Rogers, Hudson, Bretherton, Uttal
(6)	Eberhard, Hobbs, Isaac, Kogan, Rogers
(7)	Del Genio, Hobbs
(8)	Hallett, Isaac, King, Valero, Rossow, Pilewskie
(9)	Campana, Gerber, Isaac, King, Kogan, Valero, Pilewskie
(10)	Curry, Eberhard, Hobbs, Isaac, Krueger, Valero, Rossow, Pilewskie
(11)	Curry, Gerber, Hobbs, King, Kogan, Krueger, Valero, Rossow, Pilewskie
(12)	Campana, Curry, Hallett, Hobbs, King, Valero, Pilewskie
(13)	Hobbs, Isaac, Kogan, Hudson
(14)	Hobbs, Isaac, Kogan, Hudson
(15)	Isaac, Hudson
(16)	Hobbs, Isaac, Kogan, Hudson

Science Issue (Section 1.3)	<u>Investigator</u>
(17)	Hallett, Hobbs, Isaac, Kogan, Hudson
(18)	Hallett, Isaac, Lawson, Rogers
(19)	Hallett, Isaac, Rogers
(20)	Eberhard, Gerber, Hobbs, Isaac, Lawson, Q. Wang, Pilewskie, Uttal
(21)	Eberhard, Gerber, Kogan, Valero, Duynkerke, Q. Wang, Krueger, Pilewskie, Uttal
(22)	Eberhard, Gerber, Hobbs, Isaac, Kogan, Randall, Valero, Duynkerke, Q. Wang, Marchand, Krueger, Pilewskie, Uttal
(23)	Hobbs
(24)	Lawson, Hobbs, Uttal, Eberhard
(25)	Curry, Gerber, Hobbs, King, Lawson, Randall, Q. Wang, Marchand, Rossow, Pilewskie
(26)	Curry, Hobbs, Isaac, King, Kogan, Krueger, Valero, Marchand, Pilewskie
(27)	Gerber, Hobbs, Isaac, King, Kogan, Lawson, Rossow, Pilewskie
(28)	Eberhard, Hobbs, Kogan, Minnis, Rossow, Wielicki, Uttal
(29)	Del Genio, HobbsMinnis, Rossow
(30)	Minnis, Rossow, Pilewskie
(31)	Marchand, Krueger, Wielicki, Rossow, Wielicki, Pilewskie, Uttal
(32)	Marchand, Krueger, Minnis, Wielicki, Rossow, Wielicki, Pilewskie, Eberhard, Uttal
(33)	Marchand, Minnis, Hobbs, Rossow, Eberhard, Uttal
(34)	Minnis, Hobbs, Pilewskie, Eberhard

3.0 OPERATIONS COORDINATION AND OVERSIGHT

3.1 Experiment Planning, Implementation, and Oversight

The functional organization for implementing FIRE is shown in Fig. 3.1-1. A brief description of incumbent responsibilities is presented below. Appendix J provides contact information for most experiment participants.

Program Manager - Dr. Robert Curran, National Aeronautics and Space Administration (NASA) Headquarters, will be responsible for overall program guidance, review, and selection of projects and project elements, and funding.

Interagency Group (IAG) - Program managers from other programs and agencies that are responsible for assisting the FIRE Project Manager in selection of projects, project elements, and agency funding and support. Also responsible for coordinating FIRE with collaborating programs such as SHEBA and ARM. The managers are: Dr. Pam Stephens and Dr. Michael Ledbetter, National Science Foundation; Dr. Peter Lunn, Department of Energy; Dr. Richard Lawford, National Oceanic and Atmospheric Administration (NOAA); and Dr. Robert Abbey and Dr. Ronald Ferek, Office of Naval Research.

SHEBA/ARM/FIRE Joint Working Group: A group of PI's and Program Managers responsible for coordinating scientific, operational, and data issues among the three programs. Table 3.1-1 lists member names and organizations.

FIRE III Science Team - Consists of the Principal Investigators (PIs) and other selected scientists that are responsible for defining the goals of the FIRE III and monitoring the progress of individual and collective research. Dave Randall, the Co-Chair of the FIRE III Science Team is responsible for the Science, Implementation, and Operation Plans and coordination and dissemination of the Arctic Cloud Experiment final results.

Arctic Cloud Working Group- Consists of those FIRE III Principal Investigators whose investigative focus is arctic cloud conditions. Provides guidance for the design, execution and archival of results of the Arctic Cloud Experiment. The Co-Chair of the FIRE III Science Team is the Chairman of this Working Group. See Table 2.1-1.

Principal Investigators - The Principal Investigators (PIs) are responsible for the operation, data acquisition, analyses, and reporting of their respective instruments or science activities. To ensure proper exchange of information on schedules, meetings, and instrument status, each PI is responsible for designating a single person each day as their spokesperson when the PI is not in the field. The designated person will be the contact point for the appropriate Aircraft Scientist(AS), as required. This person will attend scheduled meetings, provide status on the instrument, consult with the AS as required, and will be responsible for informing co-workers of mission plans and operations.

Project Manager - David McDougal, NASA Langley Research Center, will be responsible for the overall management, coordination, and reporting of the project activities.

Lead Mission Scientist - Dr. Judy Curry, University of Colorado, will serve as the Lead Mission Scientist (LMS) and is the scientific spokesperson for the FIRE Arctic field experiment, coordinates the planning and implementation for the science objectives, conducts planning and debriefing sessions, and is the chief representative of and arbitrator for the participants in the field experiment.

Figure 3.1-1. Arctic Cloud Experiment Organization

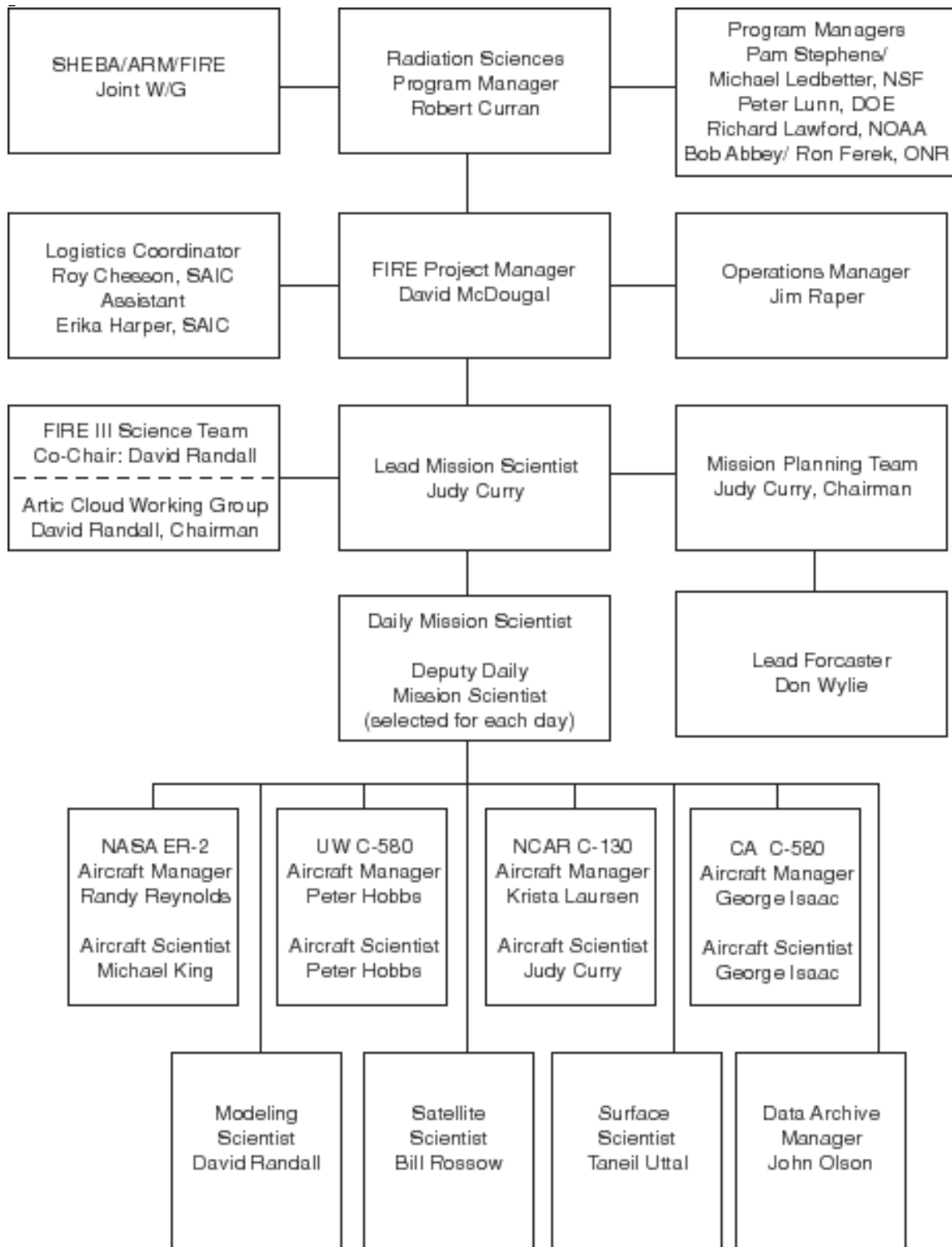


Table 3.1-1. SHEBA/ARM/FIRE Joint Working Group Members

<u>Name</u>	<u>Organization</u>
Larry Clark	NSF
Ted Cress	DOE PNL
Bob Curran	NASA HQ
Judy Curry	U. Colorado
Tom Curtin	ONR
Chris Fairall	NOAA ETL
Sivaprasad Gogineni	NASA HQ
Michael King	NASA GSFC
Mike Ledbetter	NSF
Peter Lunn	DOE ESD
Dave McDougal	NASA LaRC
Dick Moritz	U. Washington
Don Perovich	CRREL
Dave Randall	Colorado State Univ.
Bill Rossow	NASA GISS
Glenn Shaw	U. of Alaska-Fairbanks
Pam Stephens	NSF
Bernie Zak	DOE SNL

Mission Planning Team - The Mission Planning Team (MPT) for Arctic Cloud Experiment will be chaired by the LMS and includes, as a minimum, the following(or their representative): Aircraft, Surface, Satellite and Modeling Scientists; Forecaster, and Operations Manager. PIs, or their representative, at the Fairbanks Operations Center are encouraged to attend the meetings.

Daily Mission Scientist - A Daily Mission Scientist (DMS) and a Deputy Daily Mission Scientist (DDMS) will be selected by the LMS from members of the Science Team at the same time as an upcoming mission is defined. The DMS will be in charge of the detailed planning of the upcoming operations. The DMS will be responsible for making any real time decisions required during the execution of the plan. In coordination with the OM, the DMS will prepare a Daily Mission Summary. The DDMS will be responsible for assisting the DMS in all phases of the mission planning, execution, and post-mission activities, including monitoring the progression of the meteorology situation throughout the day.

Surface Scientist - The Surface Scientist, Ms. Taneil Uttal, NOAA, will provide information on the surface-based instruments located at the SHEBA ice station and at Barrow for the Daily Mission Planning meeting, monitor their operational status, and report upcoming mission plans to the surface investigators. The Surface Scientist will be the principal liaison between Fairbanks and the SHEBA and Barrow sites. The Surface Scientist will initially be located at the SHEBA Ship and later at Fairbanks.

Satellite Scientist: The Satellite Scientist, Dr. William Rossow, NASA Goddard Institute for Space Studies (GISS), will be responsible for providing information on the periods and locations of satellite observation within the experimental area. The Satellite Scientist is responsible for determining that the appropriate satellite observations are being collected, archived, and made available to the FIRE Data Archive.

Modeling Scientist: The Modeling Scientist, Dr. David Randall, Colorado State University, will be responsible for ensuring that measurements required for the Section 8.1 datasets are being collected, analyzed and archived for PI usage in a timely manner.

Aircraft Scientists - The Aircraft Scientists (AS) for the NASA ER-2 , NCAR C-130, University of Washington (UW) CV-580, and Canadian CV-580 aircraft will be responsible for implementing their respective aircraft operations plan in keeping with the scientific objectives of the day. However, it is recognized that meteorological conditions may change sufficiently on site that the aircraft operations plan may have to be modified on a real-time basis. The ASs will have sufficient latitude to implement these changes to maximize the scientific return of the aircraft measurements. This may result in a change of the scientific objectives. In addition, the ASs are responsible for representing the scientific and technical concerns of the instrument investigators at the daily mission planning meetings and serve as the single point of contact concerning upcoming mission plans and operations.

Aircraft Managers - The Aircraft Managers for the NASA ER-2, National Center for Atmospheric research (NCAR) C-130, University of Washington (UW) CV-580, and Canadian CV-580 aircraft will be responsible for the in-flight coordination between the science investigators and the flight crew and the overall integration, testing, and operation of experiments aboard their respective aircraft, including ground support operations. They will represent their aircraft at the Daily Mission Planning meetings, monitor the operational status of their aircraft, and prepare flight plans according to the mission plans.

Lead Forecaster: The Lead Forecaster, Dr. Donald Wylie, University of Wisconsin, coordinates input from the National Weather Prediction (NWP) centers and satellites and provides daily forecast support for the Daily Operations Planning meeting. The forecaster is also responsible for the collection and distribution of meteorological data products required to support the science investigators and mission operations. Key information shall be included in the Daily Mission Summaries (see section 3.6). As appropriate, some of these data products will be forwarded to the FIRE Data Archive, located at the NASA Langley Research Center (LaRC) Distributed Active Archive Center (DAAC).

Experiment Operations Manager - The Operations Manager (OM), James Raper, NASA Langley Research Center, will be responsible for ensuring that Arctic Cloud Experiment objectives can be accomplished operationally. He is responsible for providing operational facilities and infrastructure support to the Arctic Cloud Experiment operations. He will be responsible for assessing the required logistics support, canvassing the available facilities, and ensuring the acquisition of facilities, as required. The OM will receive and respond to on-site daily requests for infrastructure needs. The OM will assist the LMS in conducting the daily planning meetings, provide infrastructure to support operations, coordinate daily logs covering measurement platform and sensor operations and support activities, assist the Daily Mission Scientist in preparing mission summary reports, and distribute daily mission summary reports within 24-48 hours. The Operations Manager will also represent the FIRE Project Manager in his absence.

Logistics Support Coordinator - Roy Chesson, SAIC, is the Logistics Support Coordinator. He will provide administrative and logistical support to the Arctic Cloud Experiment Project Office, including support in the planning, coordinating, and conducting of the Arctic Cloud Experiment mission, as required. He will be assisted by Erika Harper, SAIC.

Data Archive Manager: The FIRE Data Archive Manager, John Olson, Computer Sciences Corporation, will be responsible for coordinating and assisting with all data archival. The

primary Arctic Cloud Experiment Data Archive will be located at the LaRC DAAC. Selected data of interest to FIRE investigators will only be in other archives.

3.2 Briefing, Planning, and Coordination Meetings

3.2.1 Daily Operations Planning Meeting

The Lead Mission Scientist will convene and chair a daily operations planning meeting at the Fairbanks operations site. The initial meeting will occur after completion of the Final Readiness Review. These meetings will involve all principal investigators, facility managers, instrument scientists, operations manager, forecasters, and other project support personnel that are at the operations site. The Daily Operations Planning Meetings will be open. The meetings will be held between 1500-1800 (non-flight day) and around 1700 (30 minutes after aircraft land on flight days). See section 3.3 for the daily schedules.

The agenda will include:

- 1) Reports
 - +general updates (LMS)
 - +operations during previous 24 hours (Daily Mission Scientist for Prior day)
 - +status of platforms, instruments, and resources (Instrumentation PI, Platform Manager, Operations Manager, Logistics Manager)
 - +evaluations of previous operations (Lead Mission Scientist);
 - +reports from remote sites (Surface Scientist)
- 2) Weather and surface conditions
 - +weather briefing and forecast (Lead Forecaster)
 - +report from ice camp on surface and meteorological conditions (Fairall)
 - +report from Barrow on surface and meteorological conditions (Zak)
 - +SAR analysis of the ice surface (Fowler)
- 3) Proposed operations
 - +selection of Daily Mission Scientist and Deputy(LMS)(for the first mission, tentative selections are Curry and Pinto, respectively; for the second mission, tentative selections are King and Minnis, respectively)
 - +aircraft flight plans(including primary and alternate flight tracks)(DMS)
 - +operations at remote sites(Surface Scientist)
 - +instrument failures causing no-go(Aircraft Scientists)
- 4) Discussion
 - +compatibility among proposed operations plans (LMS)
 - +progress towards FIRE objectives (LMS)
- 5) Recommendations
 - +operations for the next 24 hours, including primary and alternate missions

In the absence of a clear consensus, the Lead Mission Scientist and/or the FIRE Science Team Co-Chairman for the Arctic Cloud Experiment, will assume responsibility for making mission decisions.

3.2.2 Flight-day Meetings

A meeting will be held at least 3 hours (for the ER-2 operations) and 2 hours (for all other operations) before each flight experiment to review the latest weather information, review the flight plans, instrument status, and make a go/no-go decision. This meeting will not be used to attempt major alteration to the prime flight plan. The following should be in attendance: Lead Forecaster (or delegate), Daily Mission Scientist and Deputy Daily Mission Scientist, aircraft facility personnel, and PI's that plan to be on the flight. The meeting will be chaired by the Daily Mission Scientist.

After each flight a debriefing will be held to review all aspects of the mission from weather conditions to instrument performance. The following persons are expected to attend: Operations Manager, Mission Scientist and Deputy Mission Scientist, PI's that were on the flights.

3.2.3 Periodic Reviews

Before, after, and during the experiment, periodic Review meetings will be conducted.

Final Readiness Review/Informal Open House

Assuming the first C-130 aircraft flight will take place on May 5, 1998, there will be a Final Readiness Review at Fairbanks, chaired by the Project Manager, on the day before on May 4. Assuming the first ER-2/UW CV-580 aircraft flight will take place on May 15, there will be a Flight Readiness Review at Fairbanks, chaired by the Project Manager, on the day before on May 14. The Flight Readiness Review for the Canadian CV-580 will be a teleconference between Inuvik, Boulder and Hampton, VA on about April 7. These reviews will assess the readiness of the Arctic Cloud Experiment platforms and instruments and assure coordination of plans and support arrangements with the participants. After the Final Readiness Review has established all systems readiness, the meeting will be turned over to the LMS to conduct the Initial Mission Planning Meeting. A press conference and informal open house may be held immediately following these meetings (see section 11.11) on May 4 and 14.

Interim Experiment Review

There will be interim experiment reviews at Fairbanks, chaired by the Project Manager, at about May 5(at conclusion of Can CV-580 flights), May 29 (midway for ER-2 and UW CV-580 flights and conclusion of NCAR C-130 flights) and June 8(conclusion of ER-2 flights and near end of UW CV-580 flights). These reviews will assess the progress of the experiment to date, including mission objectives attained, aircraft flights, resources remaining, and yet-to-be attained objectives. The reviews are estimated to last about 3 hours. The principal investigator of each platform or major instrument, or a cognizant replacement, should plan to attend.

3.3 Schedules

Table 3.3-1 lists a detailed schedule of operations for the period of the Arctic Cloud Experiment. Table 3.3-2 lists the general schedule of daily operations for both flight and non-flight days. Table 3.3-3 lists daily schedule operations specific to each plane.

Table 3.3-1. Schedule of Arctic Cloud Experiment Operations

Date		Activity
April	6	Canadian Convair 580 arrives at Inuvik
	7	Canadian Convair 580 Final Readiness Review; Inuvik Open House
	7/8	Canadian Convair 580 begins operations from Inuvik
	29	Fairbanks Operations Office opens
May	1	NCAR C-130 arrives at Fairbanks
	1	Forecaster arrives Fairbanks
	4	Canadian Convair 580 finishes operations from Inuvik
	5	NCAR C-130 Survival Training at Eielson AFB
	4	NCAR C-130 Final Readiness Review; Fairbanks Open House
	5/6	NCAR C-130 begins operations from Fairbanks
	10	Interim Experiment Review(Can CV-580); Fairbanks
	13	NASA ER-2 arrives at Fairbanks; UW CV-580 arrives Barrow
	14	Final Readiness Review NASA ER-2 & UW CV-580/ Press Conference/Open House at Fairbanks
	15	NASA ER-2 and UW CV-580 begin operations from Fairbanks & Barrow
	28	NCAR C-130 finishes operations from Fairbanks
	29	Interim Experiment Review(C-130 & ER-2 & UW CV-580); Fairbanks
	30	NCAR C-130 departs Fairbanks
June	7	End of NASA ER-2 operations from Fairbanks
	8	Interim Experiment Review(ER-2 & UW CV-580); Fairbanks
	8	ER-2 departs Fairbanks for home
	8	Fairbanks Operations Office Closes
	14	U WA CV-580 Departs Barrow for home
July	6	NCAR C-130 arrives at Fairbanks; Fairbanks Operations Office reopens
	6	Final Readiness Review NCAR C-130; Fairbanks
	7	NCAR C-130 begins operations from Fairbanks
	30	NCAR C-130 finishes operations from Fairbanks
	31	Interim Experiment Review; Fairbanks
August	1	NCAR C-130 departs Fairbanks
	5	Fairbanks Ops Office closes

Table 3.3-2. General Schedule of Daily Activities at Fairbanks

Time, AST	Mission Day	Non-mission Day
0600	Forecast team arrives	Forecast team arrives
0645	Mission planning team arrives	Mission planning team arrives
0700	Meteorological Update	
0800	ER-2 GO/NO GO/DELAY decision for today's flight; Pilots' Briefing	
0900	SHEBA update	
1000	Other aircraft GO/NO GO/DELAY decision for today's flight; File flight plans for today's flights	
1000	Tomorrow's mission decision	Tomorrow's mission decision
1015	Communications to all participants	Communications to all participants
1100	Aircraft Takeoff	
~1300		NWS forecast
1300	Notify ER-2 group if flight is requested, including takeoff time, for next day	Notify ER-2 group if flight is requested, including takeoff time, for next day
1300-1400	Preliminary mission planning	Mission Planning Meeting
1500		Prelim. Notification to all participants
1600-2000	Aircraft Land	
1800-2030	Debrief of ER-2 Pilot/C-130 Scientist	
1700	Mission planning meeting	

Table 3.3-3 Schedule of Daily Activities for Specific Airplanes on Flight Day

	ER-2	UW	C-130	AES	
GO/NO GO/DELAY decision	800	1000	1000	1000	
Pilot's decision	800	1000	1000	1000	
Take-off	1100	1100	1100	1100	
Land	1730	1600	2000	1600	
Debrief	1800		2030		

3.4 Weather Forecast Support

A capability to adequately forecast cloud and weather conditions for operational planning and execution is essential. Some operational decisions involve appreciable lead times and are particularly forecast sensitive. The ER-2, based at Fairbanks, requires a three-hour lead time, at which time the pilot makes the final decision about committing to flight. This and the transit time from Fairbanks to the SHEBA ship result in a need to schedule take-off more than five hours in advance. Once prepared, take-off can be delayed but delays cannot be excessive without impacting time over the ship or return landing conditions. Thus, final decisions to commit the ER-2 to flight require a firm 4 to 10-hour forecast. There are also requirements with respect to surface weather conditions expected for landing (a forecast for excessive cross winds will cause a mission to be scrubbed). Also, there is concern about plane icing, since water is present in the clouds about 30% of the time period of the experiment.

In addition, forecasting support is also necessary for daily operations. A good 12 to 24-hour forecast is needed each evening to plan operations for the next day. This is also important for scheduling maintenance and calibration activities and ensuring high performance of Project personnel over the entire experiment, given the limited personnel (some down days will be required). A longer range outlook is also essential, since conduct of a flight may impact the ability to conduct another flight the following day. Except for the ER-2, the research aircraft are generally quite flexible. Operations may be delayed until conditions improve with little real consequence. Thus, a firm 0 to 12-hour forecast at 0300 GMT will generally be adequate.

Weather forecasts for flight operations will be divided between scientific decisions and pilot briefings. The forecasting elements will be co-located with the mission operation planning activity. Pilots will use the FAA Flight Service information as required by NASA ER-2 operating regulations. Special weather briefings and forecasts for research flight operations around and from the Ship, Barrow, Inuvik and Fairbanks will be made by the Lead Forecaster.

The forecasting plan is to use the NWS for satellite pictures, weather advice, data from the North shore, SHEBA soundings (from the GTS), and interpretation of model runs. The operations center at hangar 4 will be used to track the existence and evolution of leads and ice melt, display daily SAR images (acquired from ASF via the T1 line), conduct daily briefings, and display data products from McIDAS via Pat Minnis' computer and T1 line data from Wisconsin and GI.

Don Wylie's Univ. of Wisconsin web page (see section 9.4) includes a satellite loop of the Arctic region, with AVHRR GAC showing the whole pole and HRPT showing smaller areas. The page also shows lead analyses, cloud analyses, and cloud forecasts. Since SHEBA became operational in October, 1997, Don has put some of the SHEBA information on his web page. When the AES model output becomes available, it will be included. Prior to the experiment beginning in April 1998, satellite imagery of the arctic and the SHEBA area will be available. This homepage has four IR GAC images per day plus one HRPT 1 km image of the FIRE/SHEBA operations area. The ice camp location is marked on the images. Also on this web page are global HIRS cloud statistics.

Don will provide forecast support for the Canadian Convair 580 from his home office at the U. of Wisc. from April 7-28. He will shift operations to Fairbanks April 29 to begin supporting the C-130 and U WA CV-580 until June 13 and the C-130 from July 5-30. Pat

Minnis will also go to Fairbanks in early May and will have the Arctic web page available beginning April 1.

Pat Minnis' NASA LaRC Arctic web page(sect. 9.4) will also include HRPT loops at various scales including multispectral temperature differences for easier cloud determination

Another internet web page showing the analyses from the experiment scientists will be available during the experiment. This web page will reside at the Wainwright hangar(see section 9.4).

A daily log is prepared by the Lead Forecaster to summarize the weather conditions and is one of several inputs to the Daily Mission Summary Report(section 3.6). Appendix K, log form B, indicates the log format.

3.5 Daily Reports

All platforms and sites are requested to submit a once-daily summary of instrument operations, instrument status, frequency of operations, observer notes, data acquisition etc. to the Fairbanks Operations Center by 10 a.m. local time the following day using forms in Appendix K.

The Surface Scientist, who will be located at the SHEBA Ship, will e-mail a surface report at 7:30 a.m. local time, which should be received in Fairbanks between 8:30 a.m. and 10:00 a.m. In addition, when the data/e-mail transmission is completed, there will be a phone call at about 8:45 a.m., or if the phone lines are acting up, radio communications will be used. The radio communications will be set up in advance. The information the ship will provide is cloud heights, fraction of cloudiness for the previous 24 hours, surface temperature, sounding information from 12Z, status of lidar, radar, Ultralight, tethered balloons, etc

A Daily Mission Summary, prepared by the DMS, utilizing the once-daily summaries described above , will cover results of planned and unplanned operations for the prior day. Also to be included is an assessment of the degree to which planned and/or unplanned experiment objectives were accomplished. Appendix K, log form A, indicates the log format.

A Daily Operations Summary, prepared by the Operations Manager, will describe scheduled operations for that day, plus mission plans for the following day, and will be distributed to all persons identified in figure 3.1-1. This will also be disseminated to each remote site, including the SHEBA Ship and Barrow. The report will contain details of the aircraft operations, including overflights, times of satellite overflights, and other pertinent information. To permit adequate preparation of the surface-based sensors, the status message should outline operations in advance to the maximum degree possible, or at least by 9:30 a.m.

3.6 Daily Mission Summaries

A Daily Mission Summary will be completed for each day that there is a mission flight and for non-flight days during which there is significant or noteworthy activity. The summary will include the mission objectives, mission description, meteorological conditions, description of operations for each participating aircraft, description of surface operations, significant platform/instrument problems, mission highlights, and evaluation of the success of the mission. In addition, satellite images, aircraft flight patterns, satellite overpass

information and any other pertinent printed information concerning the mission will be attached to the summary. Appendix K gives the forms that will be used. The Daily Mission Summary will be prepared by the DMS, with assistance from the OM. It will be posted within 72 hours after operations and will become part of the Arctic Cloud Experiment data archive.

4.0 SURFACE OPERATIONS

Surface measurements operations will be conducted at both the SHEBA ship and the Barrow ARM site. The FIRE, SHEBA and ARM Projects will all three have surface instruments at the SHEBA ship site. Additionally, Don Wylie, the Lead Forecaster, will assemble numerous measurements, including rawinsondes, as a basis for his forecasting capability. Complete time records from all surface measurements are required and are to be archived for use in investigations. Time resolution should be better than 10 minutes for radiation and at least 1-hr for atmospheric and cloud properties. Appendix E provides more details about the instrumentation.

4.1 SHEBA Ship (Ice Station)

4.1.1 Overview

When sea ice forms, profound changes occur in local rates of air-sea interactions. These changes have important effects on polar and global climate over time scales ranging from a season to a century and beyond because the sea ice introduces strong feedback mechanisms into the climate system. Understanding these mechanisms poses significant intellectual challenges: How do the individual processes interact to produce the present climate? What role will these interactive processes play in the response of polar and global climate to perturbations, such as enhanced concentrations of greenhouse gas in the atmosphere? The general circulation model (GCM) is the most comprehensive tool that has been used to address such questions. Numerous experiments performed with GCMs over the past 15 years support two important conclusions:

- Interactions among sea ice, atmospheric radiation, and clouds in the Arctic exert a strong influence on the model-simulated global climate and climate sensitivity.
- Uncertainties in the formulations of interactive air-sea-ice processes result in large differences between the arctic and global climate simulated by different models. In simplest terms, the principal uncertainties can be characterized as ice-albedo feedback and cloud-radiation feedback.

In response to these conclusions and to increasing scientific interest, U.S., Russian, Norwegian, and Canadian investigators have envisioned SHEBA as a 5-year research project. The primary goals of SHEBA are: (1) to develop, test, and implement models of arctic ocean-atmospheric-ice processes that demonstrably improve simulations of the present day arctic climate, including its variability, using General Circulation Models (GCMs), and (2) to improve the interpretation of satellite remote sensing data in the Arctic so that satellites can assist effectively in the analysis of the arctic climate system and provide reliable data for model input, model validation, and climate monitoring. To accomplish these goals, SHEBA will integrate three components: a field experiment, satellite remote sensing, and modeling. It is anticipated that the field experiment will be staged from a 13-month drifting sea ice camp in the Arctic Ocean to be established in September 1997.

The centerpiece of the SHEBA measurement program is a 13-month coordinated experiment to be conducted on the drifting pack ice of the Beaufort Sea. A wide variety of instruments will be deployed over a region of pack ice surrounding the SHEBA logistics platform. In September 1997 the N.G.C.C. Des Groseilliers, along with the N.G.C.C. Louis St. Laurent traveled north in the Beaufort Sea in the general vicinity of 75 N, 145 W.

The Des Groseilliers moored to a large floe and will drift with the pack ice until October 1998. This will be the principle research platform for the SHEBA field observations.

The Des Groseilliers is an ice-strengthened ship which penetrates approximately 300 km into the multiyear pack ice during late summer 1997, positions itself near a multiyear ice floe of significant size, and is frozen in place during October-November, 1997. The ship and all of the surrounding measurement sites will drift with the pack ice for approximately 13 months, i.e. through approximately 15 October, 1998, at which time the measurement program will end and the ship will sail out of the pack and back to port. Plans call for the ship itself to serve as the hotel for all participants in the surface program, and to provide power, laboratory space, staging areas, shop facilities, computer network, communications, and all infrastructure for the science program. See appendix F for more information on the SHEBA ship site.

4.1.2 Ice Station Personnel and Management

SHEBA has established a Project Office at the Polar Science Center, University of Washington (R. Moritz, Director). This office is the contact point for coordination between SHEBA and FIRE in the areas of logistics, data management and distribution, infrastructure support and general information and communications. The SHEBA Project Office maintains a home page on the internet web that provides important information about logistics, data management and distribution, and coordination between programs such as SHEBA, ARM, FIRE, RGPS and SCICEX.

The WEB address is included in Table 9.4-1. The SHEBA Project Office is responsible for developing agreements between SHEBA and cooperating programs that document the mutual commitments and responsibilities of these programs. These "Participation Agreements" are posted on the SHEBA home page on the web.(see section 9.4) The SHEBA/FIRE agreement is Appendix L.

The SHEBA Logistics Office has been established at the Polar Science Center, University of Washington, to plan, manage and coordinate the logistics, operational support, and field services for the SHEBA field experiment. The Logistics Office will serve as the U.S. contact point for coordination of all logistics and operational support for SHEBA and ancillary science projects, including those funded by other agencies and organizations that are conducted in conjunction with SHEBA. The Logistics office is directed by A. Heiberg.

The SHEBA Phase 2 Extended Abstracts, which describe the various scientific elements of the SHEBA Project can be found at the WEB address included in Table 9.4-1.

The Chief Scientist will have overall responsibility for the science program, and will have the authority to make decisions concerning priority and allocation of resources to science projects when such decisions are necessary. The SHEBA Science Team will appoint the Chief Scientist(s) so that there will always be a designated Chief Scientist on site. The Chief Scientist will be the formal liaison between the Scientific personnel and the logistics support personnel.

The Management of the field phase of the Project requires that certain responsibilities and lines of authority be defined. In the field, decisions related to safety and the science program will be the responsibilities of the Ship's Captain, the Logistics Office person in Charge, the Chief Scientist, and the Project Office, with detailed responsibilities yet to be worked out.

Appendix L contains the Participation Agreement between SHEBA and NASA.

4.1.3 Surface-Based Instrumentation

SHEBA plans to select a central site on undeformed multiyear ice within a few hundred meters of the ship, where a comprehensive time series of measurements will be made for the entire 13-month SHEBA experiment. The measurements will include observations of the radiation fluxes, the properties of the atmosphere, the atmospheric fluxes, the ice temperature and mass balance, the interaction of shortwave radiation with the ice, the ocean heat and momentum fluxes, and the properties of the upper ocean. See Appendix E for further information about all surface instrumentation.

The incident shortwave and longwave radiation fluxes will be measured in detail by the DOE sponsored Atmospheric Radiation Measurement Program (ARM). The cooperative agreement between SHEBA and ARM is defined in a Memorandum of Understanding. The Agreement between ARM and FIRE is included in Appendix P. ARM will provide a suite of ship-based instruments that will measure the incident shortwave and longwave radiation fluxes. A shadow-band radiometer will be used to determine the direct and diffuse components of the incident shortwave irradiance will be measured. Both wavelength-integrated and spectral measurements of the incoming shortwave and shortwave irradiance will be made. The details of the ARM contribution to SHEBA are specified in the ARM/SHEBA Memorandum of Participation.

The ARM instruments that will be at the ice camp include:

- precision upwelling and downwelling infrared radiometer
- precision upwelling and downwelling shortwave spectral pyranometer
- net radiometer
- Multi-filter Radiometer (upwelling solar)
- infrared thermometer
- normal incidence pyranometer (tracking, broadband)
- Multi-filter Rotating Shadowband Radiometer (spectral downwelling solar)
- Extended Range Atmospheric Emitted Radiance Interferometer
- microwave radiometer
- ceilometer
- Whole Sky Imager

FIRE will provide two sets of instrumentation at the SHEBA ship. One will be Peter Pilewskie's solar spectral flux radiometer which will provide a measure of downwelling irradiance at the surface. Spectral and bi-directional reflectance and transmittance, surface spectral albedo, cloud phase and optical depth will also be available.

The second set of FIRE instrumentation will be Peter Duynkerke's IMAU tethered balloon, surface and tower instrumentation. Measurements of wind velocity and direction, temperature, humidity, pressure, actinic flux, moisture, up and downwelling solar and longwave radiation and liquid water path will be available. Details of the FIRE measurements are included in Appendix E. Appendix L presents the SHEBA/FIRE participation agreement.

The following paragraphs generally describe the SHEBA instrumentation and Appendix E provides further details.

To measure cloud properties, a tethered balloon with microphysical and radiation packages, a vertically pointing 35 GHz cloud radar (MMCR), and a dual-polarization and backscatter unattended lidar (DABUL) with capability to scan horizon to horizon will be deployed. The radar and lidar will run continuously for the 14 month duration of the SHEBA experiment, the balloon launches will be conducted between March and September of 1998. Launch frequency will depend on weather and the plan is to capture the transition from ice clouds to mixed-phase clouds to warm clouds in the spring and fall. Results from the surface-based radar and lidar, along with observations from the tethered balloon will be used to investigate:

- cloud boundaries
- cloud microphysics
- cloud phase
- aerosol structure

Two tethered balloons will be used to investigate the properties of the lower 1 km of the atmosphere. A small balloon (3 m³) will be used for routine measurements of temperature, humidity, wind speed and direction in the boundary layer. A larger balloon (9 m³) platform with the capability of providing power up-the-tether and data down-the-tether will be used to measure profiles of cloud microphysical parameters, mean radiative intensities (actinic flux) using a 4-pi sensor (with isotropic response), and meteorological parameters (temperature, humidity, wind speed and direction) in the lower 1 km of the atmosphere. The tethered balloon effort will measure:

- vertical profiles of temperature and humidity in the lower 1 km of the arctic boundary layer at the SHEBA ice camp, on a routine basis;
- vertical profiles of cloud microphysical parameters in the lower 1 km of the arctic boundary layer between mid-March and mid-October with increased frequency between April and June, which is the transitional period between ice and water phase of arctic clouds;
- mean radiative intensities using a 4-pi sensor (with isotropic response), and meteorological parameters (temperature, humidity, wind speed and direction).

Atmospheric conditions will also be studied using rawinsondes. The NCAR Surface and Sounding Support Facility (SSSF) will support the ground station and expendables for the radiosonde observations at the ship. The system to be used is a GPS Atmospheric Sounding System (GASS) and a total of 830 sondes has been requested. The soundings will be made at 00Z and 12Z everyday during the SHEBA year. During the time of FIRE airplane flights, an additional 2 soundings per day will be obtained as a result of a FIRE funding augmentation to SHEBA. At every launch two messages will be sent to the GTS, first a preliminary message before the sounding is completed and then a second after the sounding is finished. The target maximum altitude for each ascent is 20 mb. A slower

ascent rate within the boundary layer will be obtained through the use of a ballast device, conditions and staffing levels permitting. The launch time is about 30 min before the synoptic time and the total time for preparation, launch, monitoring, message preparation, and archiving is about 3 person/hours per launch. The balloon launches will be performed by the SHEBA Project Office weather observers. The balloons will be inflated in the helo hangar on board the ship and will be released by hand on the helo deck.

The properties of the near-surface atmospheric boundary layer will be investigated using a 20-m atmospheric flux and profiling tower at the central site. This will be instrumented at (nominally) 3, 5, 10, and 20 m. The instruments at each of these level will be:

- 3-axis sonic anemometer/thermometer for measuring the turbulent fluxes of momentum and sensible heat by eddy-correlation
- slow-responding temperature and humidity sensors for measuring profiles
- slow responding anemometers and vanes for measuring wind speed profiles
- at 3 and 10 m, there will be fast-responding hygrometers for measuring the turbulent flux of latent heat by eddy-correlation.

Next to this main tower will be an elevator tower capable of lifting instruments from near the surface to 10 m. This will facilitate near-surface profiling and instrument calibration. This elevator tower will have slow-responding temperature and humidity sensors and either a 3-axis sonic anemometer/thermometer or a propeller-vane. Near this main tower, there will also be upward and downward-looking pyranometers and pyrgeometers to complement the ARM radiation measurements and remote radiation measurements.

Lastly, in the vicinity of our main tower, we will have a scintillometer system. This system propagates a 0.67-micrometer laser beam over a 400-m horizontal path 2-4 m above the surface and thereby yields path-averaged values of the refractive index structure parameter, the inner scale, and the turbulent fluxes of momentum and sensible heat. These measurements provide intermediate-scale values for aggregating considerations. In the immediate vicinity of the transmitter, this laser is not eye-safe. SHEBA personnel must be warned of this hazard.

Detailed measurements of the optical properties of the ice will be made at the central site. There will be routine visits to the site to make detailed optical measurements of (1) spectral and total values of incident irradiance, (2) albedo. During these visits the physical properties of the snow and ice will be characterized. This will include measurements of snow depth, density and grain size, as well as ice temperature, salinity, density, brine volume and air volume.

Aggregate-scale snow properties will be investigated via a series of traverse lines ranging up to 20 km in length. These lines will be centered on the SHEBA camp and will be oriented so they intersect a wide range of conditions. Data on snow depth, density, water content, and bulk thermal properties will be collected at a variety of sampling intervals ranging from 10 cm spacing on 100 m lines to 1 m spacing on lines of a kilometer or more to document the full range of spatial variance. Measurements will be made using an

FM-CW radar, automated depth probes, hand probes, snow pit measurements, laser leveling systems and well-established field protocols. We will collect snow data as a function of ice type and floe morphology to determine how the spatial distribution and characteristics of the snow cover are related to ice type, age and ridging.

Repeated surveys will be carried out to obtain statistics on spatial and temporal variability in albedo, data needed for extrapolating local scale measurements to the aggregate scale. Spectral and total albedos will be measured every few meters along several hundred meter long traverse lines. At least one of these lines will be collocated with the ARM site. Surveys will be conducted every 1-2 weeks during the spring when the ice is snow-covered, but will be made 2-3 times per week during the summer when conditions are changing rapidly. We also hope to make similar surveys of spectral transmittance beneath the ice. Because of practical constraints, these surveys will be made less frequently and only for short subsections along the albedo traverses.

4.1.4 Mesoscale Array

SHEBA will deploy 13 drifting buoy stations in a 250 km array (Figure 4.1.4-1 and Table 4.1.4-1) with ARGOS telemetry data. These buoys provide the regional weather context for the experiment and bound the calculation of the surface temperature field in a 70 km x 70 km area. All locations provide temperature data. An outer array of 3 buoys at 150 km radius (not shown) and 4 buoys at 50 km radius from camp measure sea-level pressure.

Four locations and the main camp provide long and short wave radiation measurements with PAM stations. Except for one radiometer pair, the radiometers are deployed in line to measure the spatial correlation of incoming radiation over distances of 10-75 km. The four radiation sites will be augmented with mass balance instrumentation. This will include a thermistor string that extends through the ice sheet and into the air and water near the respective interfaces. Sonic sounders are placed above and below the ice cover to detect the location of the ice-air and ice-water interfaces. Manually-operated thickness gauges will also be placed at these sites. These gauges will be read whenever the remote stations are visited. All of this equipment will be wired to a CR-10 data logger. The data loggers will be equipped with enough storage modules to get through the winter, until the helicopter arrives back on the scene in spring.

All pressure, temperature, and radiation sensors will be carefully intercalibrated before the experiment.

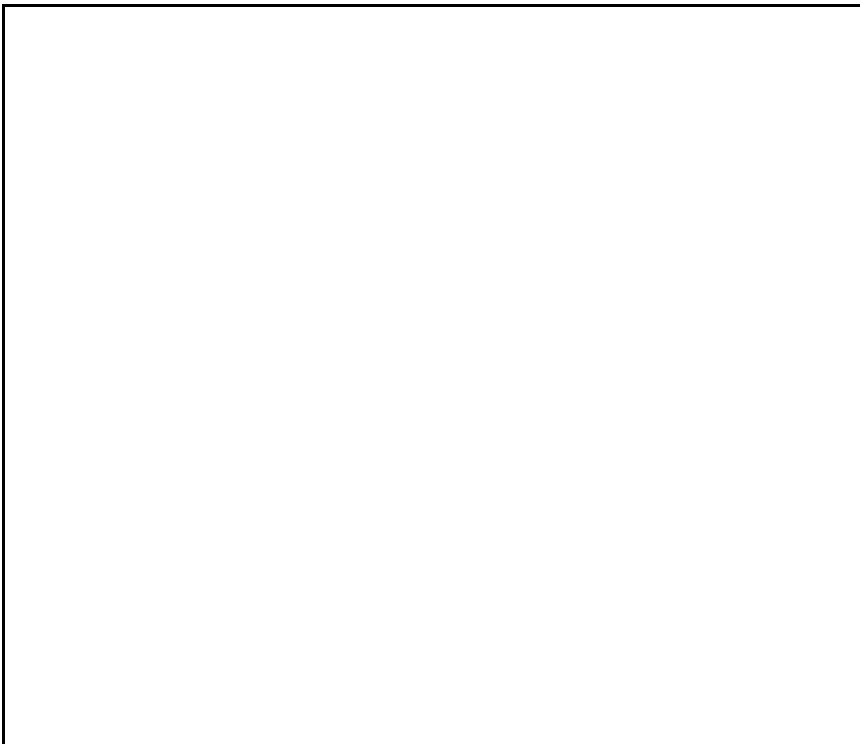
Appendix E, section E.5 lists the instrumentation on the buoys and at the PAM stations.

Table 4.1.4-1 Buoy Locations and Instrumentation

Site	Instruments	Distance, km
1	Pop buoy, radiometers, mass balance with pingers, acoustic sensor, stress sensor	50
2	Pop buoy, radiometers, mass balance with pingers, acoustic sensor, stress sensor	50
3	GPS, radiometers, mass balance w/o pingers	25
4	GPS, radiometers, mass balance w/o pingers	25
5	IOEB, acoustic sensor, stress sensor	
6	JIC buoy	50

Site	Instruments	Distance, km
7	JIC buoy	80-100
8	JIC buoy	80-100
9	GPS, stress	15
10	GPS, stress	15
11	GPS, stress	15
12	GPS	15
13	JIC buoy	80-100

Figure 4.1.4-1. Schematic of buoy array around the SHEBA ship.



Five of the buoys will be provided by the Joint Ice Center (JIC) and two of the buoys will be provided by McPhee/Morrison. The balance of the array is provided through Pacific Marine Environmental Laboratory (PMEL). The two McPhee/Morrison buoys will have oceanographic sensors and three buoys located at 15 km from the station will have seacats. PMEL will provide the coordination for deployment of the buoy array. The array will be deployed in the fall and the stations need to be visited in the spring to check the radiometer installations. All equipment, except the JIC buoys and one radiometer pair, will be recovered at the end of the experiment.

4.2 ARM Barrow Site

4.2.1 Overview

The North Slope of Alaska/Adjacent Arctic Ocean Cloud and Radiation Testbed (CART) site will provide data about cloud and radiative processes at high latitudes. These data will be used to refine models and parameterizations as they relate to the arctic. NSA/AAO will be centered at Barrow, and extend to the south (to the vicinity of Atkasuk), west (to the vicinity of Wainwright), and east (perhaps to Oliktok). The Adjacent Arctic Ocean will be probed by the Surface Heat Budget of the Arctic (SHEBA) experiment, a multi-agency program led by the National Science Foundation and the Office of Naval Research. SHEBA involves the deployment of an instrumented ice camp within the perennial Arctic Ocean ice pack to be manned in the autumn of 1997 for 12 months.

The ARM North Slope of Alaska homepage URL is included in Table 9.4-1.

Scientific objectives for the NSA/AAO site are provided below:

Provide the comprehensive data sets necessary to develop and test continually improved algorithms for GCMs to describe radiative transfer and cloud processes at high latitudes; Specifically focus on development of algorithms to describe:

1. radiative transfer within both the clear and cloudy atmosphere, especially at low temperatures;
2. physical and optical behavior of water (ice) and land surfaces, both bare and snow-covered, especially during transitions from winter to summer and back;
3. physical and optical behavior of ice and mixed phase clouds .

Temporal Priorities (issues to be pursued first, second, etc.):

1. Infrared radiative transfer under cloudless skies for very cold, dry conditions. This issue pertains to both high latitudes and high altitudes (Instantaneous Radiative Flux (IRF) experiment).
2. Influence of stratus clouds on solar radiative transfer near the surface. Start with liquid water clouds; next go to ice clouds; attack mixed phase clouds last (in order of increasing measurement challenges). This issue pertains to the influence of stratus clouds, and to high altitude ice (cirrus) clouds worldwide (IRF experiment).
3. Influence of stratus clouds on infrared radiative transfer near the surface. Start with liquid water clouds; next go to ice clouds; address mixed phase clouds last. This issue has the same broad applicability as number 2 above.
4. Solar radiative transfer to the surface under cloudless skies (IRF experiment).
5. Interactions of surface albedo and related optical and physical factors with surface heating (SOM: Surface Optical Model experiments).
6. Local factors affecting the formation and properties of stratus clouds (Cloud Behavior (CB) experiments; horizontal measurement scale, few km; eg. coastal, open lead, snow cover edge, lake and other discontinuity effects).
7. Stratus cloud formation and evolution processes on GCM grid cell scales (Cloud Behavior/Single Column Model (CB/SCM) experiments).

Note that the temporal priorities are based in part upon the breadth of the instrumentation resources required to address each issue. Issues with higher temporal priorities can be addressed earlier in the NSA/AAO CART site development. Lower temporal priorities cannot be addressed until much more of the site instrumentation suite is in place and operating. Nevertheless, progress on each one of these issues is critical to the achievement of the NSA/AAO scientific objectives, and to the achievement of the overall goal of more accurate global and regional future climate predictions.

4.2.2 Instrumentation

Cloud Observation Instruments

- Vaisala Ceilometer (VCEIL)
- Millimeter-Wavelength Cloud Radar (MMCR)
- Micropulse Lidar (MPL)
- Whole-Sky Imager (WSI)

Radiometric Instruments

- Cimel Sunphotometer (CSPOT)
- Downward Pointing MFR (GNDMFR)
- Extended-Range Atmospheric Emitted Radiance Interferometer (ER-AERI)
- Infrared Thermometer (IRT)
- Multifilter Rotating Shadowband Radiometer (MFRSR)
- Net Radiometer
- Normal-Incidence MFR (NIMFR)
- Pyranometers
- Pyrgeometers
- Pyrheliometers
- Radiometric Instrument Systems
 - ARCS Upwelling Radiation (GNDRAD)
 - ARCS Downwelling Radiation (SKYRAD)
- Ultraviolet-B Radiometer (UV-B)

Surface Flux and Surface Characterization Systems (Non-radiometric)

- Infrared Thermometer (IRT)

Surface Wind, Temperature, and Humidity Sensors

- Surface Meteorological Observations

Wind, Temperature, and Humidity Sounding Systems

- Microwave Radiometer (MWR)
- Ground-based REMote Sensing Systems for Temperature and Humidity Profiles

4.3 Forecast Operations

The following data products and capabilities are needed for proper mission planning and conduct:

- AVHRR loops (remapped to the Arctic Basin grid)
- Surface/upper air products
- Ice Station measurements - surface weather, ARM data stream including lidar (available near real time via internet), upper air soundings, personal weather descriptions (via telephone/fax)
- ARGOS buoy network (10 buoys within our sector; on GTS)
- Barrow measurements (also over Internet)
- Wx model forecasts : - AES, ECMWF, Fairbanks NWS Arctic Basin, University of Alaska,, Purdue University, University of Wisconsin McIDAS, and NCEP
- Pilot Briefing Capability-Ft. Wainwright, Prudhoe, Inuvik, Barrow (forecasts from Fairbanks), and Atkasuk

Internet access is imperative for the access to some of these data products.

The Lead Forecaster will collect satellite and weather data for briefing the team scientists. The weather data will come from three sources: 1) the National Weather Service, 2) the University of Alaska Geophysics Institute, and 3) the University of Wisconsin-Madison.

The Fairbanks office of the National Weather Service will graciously allow NASA

scientists to view their data in their office and discuss weather issues with their forecasters. This will be the main source for developing weather and cloud forecasts during the experiment. The McIDAS system will be used for acquiring satellite imagery and will be accessed by Pat Minnis' computer fed by data from Wisconsin and Geophysical Institute (GI). The NWS has its own system which is not part of AFOS. It will remap Polar Orbiter data to 1.5 km scale over the Arctic Basin so that leads will be visible. However, the NWS data and meteorological displays cannot be easily exported outside of their office for use in the Operations Center at Fort Wainwright and for the experiment archive, i.e. no Internet outlet. While there is one work station available, it is not outgoing connected. Don Wylie will request whether we can put some of these products on our real time homepage and on his website. Weather information from the GI may be able to be transmitted from GI to hangar 4 at Wainwright via an existing T1 line.

Since we cannot archive NWS-Fairbanks satellite data, Don Wylie will archive GAC and some HRPT data at Wisconsin. Pat Minnis will archive HRPT acquired from the GI. Pat Minnis estimates that real time HRPT data that normally goes to North Dakota can be acquired for about \$2K. Jim Moore indicates that SHEBA will be acquiring HRPT data from GI.

Satellite data will be obtained from both the University of Alaska-Fairbanks Geophysical Institute and from the University of Wisconsin-Madison. The high resolution NOAA AVHRR HRPT data will be gathered by the University of Alaska for the part of the arctic covering the area of SHEBA and aircraft operations. SAR data also will be collected from the University of Alaska Geophysics Institute and transmitted to the Operations Center after a delay of several days. Other larger areal coverage of lower resolution will be collected at the University of Wisconsin-Madison from the operational NOAA satellites. These data will be used for daily tracking weather systems, clouds and ice patterns.

A McIDAS will be installed in the Fairbanks Operations Center for displaying satellite data and briefing the experiment operations. It also will be used for analyzing satellite imagery for the structure of leads in the ice and clouds in preparation for the research flights. The McIDAS will be electronically connected to the Universities of Alaska and Wisconsin for obtaining the satellite data.

Acquisition of rawinsonde and other surface-based remote sounding data will be important to the success of the Arctic Cloud Experiment. These data are crucial to the success of efforts to model arctic cloud development on the large scale and to characterize arctic cloud development at smaller scales. Accurate knowledge of atmospheric temperature structure is essential for analysis and modeling of infrared radiative transfer in arctic clouds, for inferring arctic cloud properties from satellite observations, for assessing the effects of arctic clouds on the surface and TOA radiation budgets, for analysis and modeling of atmospheric radiative transfer, and for analysis of surface-based remote sensing observations of arctic clouds. SHEBA rawinsonde data is in the NWS archive under the identifier CGDX along with data from other sites. SHEBA Ship data is also included in the SHEBA archive--SHEBA homepage/On-line Catalog/Glas_txt_data for tabular data or GLAS_skewt for a graphical plot. See section 9.4 for SHEBA homepage URL.

4.4 Instrumentation Operation Logs

Appendix K includes the instrumentation operations logs. These logs provide daily information about instrument operations and provide one of several inputs into the Daily Mission Summary Report, section 3.6. The Surface Scientist prepares these logs daily based upon communication with the instrumentation sites. Table 4.4-1 indicates the log in Appendix K for each site.

Table 4.4-1. Instrumentation Operations Logs Summary

<u>Subject</u>	<u>Log Identifier</u>
Barrow/ARM	Q
Ship/ARM	O
Ship/SHEBA	N
Ship/FIRE	P

4.5 Survival Training

Andy Heiberg will conduct training sessions upon arrival at the SHEBA Ship for those to be stationed at the Ship. No personal firearms are permitted at the Ship. Appropriate firearms will be provided during the training. Each person going to, or remaining at, the Ship is required to have a signaling mirror, whistle and sleeping bag (designed for extreme cold). These items must also be personally carried during aircraft transit to and from the Ship. Questions should be directed to Fred Karig at 206-543-1354 or Andy Heiberg at heiberg@shebашip.apl.washington.edu.